## Chapter 3

# Small Mammal Inventories in the East and West Usambara and South Pare Mountains, Tanzania. 3. Chiroptera

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## Abstract

Whereas the terrestrial mammal fauna of the East and West Usambara Mountains have been the subject of numerous investigations, the local bat fauna remains poorly documented, as is the case for bats of the South Pare Mountains. During mammal surveys of these three massifs, we used mist nets to collect local bats, documenting 20 bat species in total.

In the Usambara Mountains, 161 individual bats representing 19 species were documented during the three years of the survey between 1991 and 1993. In the East and West Usambara Mountains, 17 and 12 species, respectively, were recorded. Most animals were taken in net sets placed outside or at the edge of forested habitats. In the South Pare Mountains, 67 bats representing six species were collected during the two surveys, including 62 bats of six species at 1100 m (surveyed 17–29 July 1993) and five bats representing three species at 2000 m (surveyed 19–28 August 2004). Based on our morphological studies, no evidence of undescribed taxa in these collections exists.

Species common across all three massifs include two pteropodids (*Epomophorus wahlbergi* and *Lissonycteris angolensis*), one rhinolophid (*Rhinolophus clivosus*), and one vespertilionid (*Neoromicia capensis*). Taxa only captured on a single massif include *Rousettus lanosus* and *Rhinolophus simulator* (South Pare, 10% of total captures), *Myonycteris relicta* and *Nycteris thebaica* (West Usambara, 10% of total captures), and *Rousettus aegyptiacus*, *Rhinolophus deckenii*, *R. fumigatus*, *R. swinnyi*, *Nycteris grandis*, *Myotis bocagei*, and *Scotophilus viridis* (East Usambara, 35% of total captures).

Comparisons of capture rates and species richness between these three montane sites to more lowland forest sites indicate a notable reduction in species richness and density with increasing elevation. Our preliminary surveys are at best rough estimates of patterns of species diversity and richness in the montane portions of these massifs; more fieldwork and associated taxonomic work are clearly needed to have more in-depth knowledge of the local bat fauna.

## Introduction

The bat fauna of Tanzania is diverse but poorly known (Monadjem et al., 2010). Studies of the country's bat fauna have discovered several species new to science in different habitats (Kock & Howell, 1988; Stanley, 2008), documented taxa that were previously unrecorded (Stanley & Foley, 2008), or collated and summarized information about a particular taxonomic group (Harrison, 1971; Bergmans, 1988, 1994, 1997; Csorba et al., 2003). Whereas the terrestrial mammal fauna of the Eastern Arc Mountains has been the subject of biological investigations for decades (see Stanley et al., this volume), the local bats have only recently been inventoried (Stanley et al., 2007a,b). Studies by Dieter Kock, in particular, largely based on specimens obtained by Kim Howell, highlighted aspects of this fauna (i.e., Kock & Howell, 1988; Kock et al., 2000); our knowledge of the fauna of montane habitats outside the Usambaras has also been augmented (Stanley et al., 2000, 2005a,b,c). During small mammal surveys in the East and West Usambaras (see Stanley et al., this volume) and South Pare Mountains (Stanley et al., 1996, 1998), we trapped and collected bats. Herein we present information on the bat taxa obtained and the associated natural history data from portions of the East and West Usambara Mountains and South Pare Mountains.

## Study Area

Descriptions of our study sites in the montane portions of the East and West Usambara Mountains are presented in Stanley et al. (this volume). Specimens collected in the South Pare Mountains are from two localities: (1) Chome Forest Reserve, 7 km S Bombo, 4°20′S, 38°0′E, 1100 m (surveyed 17–29 July 1993) and 3 km E, 0.7 km N Mhero, 4°17′10″S, 37°55′40″E, 2000 m (surveyed 19–28 August 2004). Details of the ecological settings of these sites are given in Lovett and Pócs (1993) and Stanley et al. (1996, 1998). Both of the South Pare sites are submontane forests (sensu Lovett & Pócs, 1993), but the 1100-m site was notably drier than the 2000-m site.

Forested and agricultural sites on the Bulwa, Kwamkoro, and Monga Tea Estates in the East Usambara, and the Ambangulu Tea Estate in the West Usambara were sampled between 1991 and 1993. Specific dates of surveys in the East Usambara were 05–09 August 1991, 19 July–24 August 1992, and 30 July–13 August 1993 and in the West Usambara were from 01–31 July 1991, 27 August–04 September 1992, and 18–22 August 1993.

## Methodology

### Capture Techniques

Although the chiropteran fauna was not the principal focus of our small mammal surveys in the montane areas of the East and West Usambara and South Pare Mountains, efforts were made to trap bats at the different inventory sites. Bats were captured using mist nets (12 m long, 3 m high, five-tiered) erected in an opportunistic manner in various settings, including over streams, across forest paths or near standing bodies of water. In the East and West Usambara Mountains, bats were occasionally found in nets (of the same dimensions) set by William D. Newmark for a project monitoring the effects of forest fragmentation on understory birds (Newmark, 1991, 2006). These nets, referred to herein as "bird nets", were set (parallel) along the central portion of cleared paths in the understory of different sizes of forest parcels, with the lowest rung touching the ground, and open from dawn to 1900 h.

### Specimens and Taxonomy

Bat specimens were either prepared as skins with associated skulls and axial skeletons or fixed in formalin. Tissues, including heart, liver, and kidney, were frozen in liquid nitrogen. All specimens are deposited in the Field Museum of Natural History (FMNH), Chicago. We follow herein the taxonomy of Simmons (2005) for bats, except the genus *Miniopterus* is assigned to a separate family, the Miniopteridae (Hoofer & Van Den Bussche, 2003; Miller-Butterworth et al., 2007). FMNH catalogue numbers are presented for each voucher specimen.

### Measurements

All measurements are in millimeters, except weight, which is in grams.

External Measurements—External measurements of collected specimens were made in the field before preparation following DeBlase and Martin (1974) using a plastic ruler marked in millimeters. The measurement methodology of each field worker varied in some cases. For this reason and similar problems highlighted by Blackwell et al. (2006), external measurement statistics are separated by collector.

| | |
|---|---|
| TL | total length (from the tip of the nose to the last caudal vertebra) |
| HB | head and body length (from the tip of the nose to the junction of the tail and the body) |
| TV | length of tail vertebrae (from the junction of the tail and body to the last caudal vertebra) |
| HF | hind foot length (from the ankle to the tip of the longest claw for W.T.S.; ankle to insertion of claw for S.M.G.) |
| FA | forearm length (from outside edge of wrist to outside edge of the elbow of the folded wing) |
| EAR | ear length (from the notch at the base of the ear to the longest point of the ear) |
| TR | tragus length (from base to distal-most tip of tragus) |
| WT | weight (measured with Pesola scales) |

Cranial Measurements—Cranial measurements were taken with digital calipers to an accuracy of 0.01 mm (by W.T.S.) on cleaned skulls of adult bats, defined as animals with a fully erupted third upper molar and the suture between the basioccipital and basisphenoid bones fused. These measurements vary between different genera and follow the definitions (but not necessarily the abbreviations) listed by Bergmans (1988) for *Epomophorus*, Kock et al. (2000) and Csorba et al. (2003) for *Rhinolophus*, and Bates et al. (2006) for vespertilionids.

| | |
|---|---|
| ALSW | greatest width of the anterior lateral swellings on the rostrum of *Rhinolophus* |
| AMSW | greatest width of the anterior median swellings on the rostrum of *Rhinolophus* |
| BW | greatest width of braincase |
| CBL | greatest length from occipital condyles to front of premaxilla |
| CCL | greatest length from occipital condyles to anterior surface of upper canines |
| CIL | greatest length from occipital condyles to anterior-most point of upper incisors |
| CRN | greatest length from posterior-most point of cranium to front of premaxilla |
| GLS | greatest length from posterior-most point of cranium to anterior surface of upper canines |
| GSKL | greatest length from posterior-most point of occipital to anterior-most point of upper incisors |
| IOW | least interorbital width |
| LW | greatest breadth across rostrum at lachrymal projections |
| MAND con | greatest length from anterior-most point of the mandible (not including incisors) to the condyle |
| MAND ang | greatest length from anterior-most point of the mandible (not including incisors) to the most posterior end of angular process |
| MAND HT | the perpendicular greatest height of mandible, measured by placing the mandible on a microscope slide and measuring from the bottom of the slide to the top of the coronoid process and subtracting the thickness of the slide from the total |
| MAST | mastoid width |
| PAL | length of palate from posterior margin of the palate (at the median plane in Pteropodidae, to the side of any median projection in insect-eating bats) to the front of the premaxilla, or maxilla in *Rhinolophus* |
| POW | postorbital width |
| ROST | length of rostrum between anterior-most point of the orbit margin and the front of the premaxilla |
| ZYG | zygomatic width |

Dental Measurements—

| | |
|---|---|
| C-C cing | greatest distance from the labial side of the cingulum of one upper canine to the labial side of the cingulum of the other canine |
| C-C alv | greatest distance from the labial side of the alveolus of one upper canine to the labial side of the alveolus of the other canine |

TABLE 1. Bat species represented by specimens collected during our surveys in the East and West Usambara and South Pare Mountains between 1991 and 1994. The two sites sampled in the South Pare Mountains differed in elevation by 900 m and are presented separately.

| Species | East Usambara (900–1150 m) | West Usambara (1150–1300 m) | South Pare (1100 m) | South Pare (2000 m) |
|---|---|---|---|---|
| *Epomophorus wahlbergi* | X | X | X | |
| *Lissonycteris angolensis* | X | X | X | X |
| *Myonycteris relicta* | | X | | |
| *Rousettus aegyptiacus* | X | | | |
| *Rousettus lanosus* | | | X | |
| *Rhinolophus clivosus* | X | X | X | X |
| *Rhinolophus deckenii* | X | | | |
| *Rhinolophus fumigatus* | X | | | |
| *Rhinolophus hildebrandti* | X | X | | |
| *Rhinolophus simulator* | | | | X |
| *Rhinolophus swinnyi* | X | | | |
| *Nycteris grandis* | X | | | |
| *Nycteris thebaica* | | X | | |
| *Glauconycteris argentata* | X | X | | |
| *Myotis bocagei* | X | | | |
| *Scotophilus dinganii* | X | X | | |
| *Scotophilus viridis* | X | | | |
| *Pipistrellus hesperidus* | X | X | | |
| *Neoromicia nanus* | X | X | X | |
| *Miniopterus schreibersii* | X | X | | |
| Total no. of species | 16 | 11 | 5 | 3 |

| | |
|---|---|
| $I^1$-$M^3$ | greatest length of upper toothrows, from the upper incisor to the last upper cheektooth measured at the alveoli |
| $I_1$-$M_3$ | greatest length of lower toothrows, from the lower incisor to the last lower cheektooth measured at the alveoli |
| lowermols | length of lower molariform toothrow |
| LUTR | greatest length of upper toothrows, from the upper canine to the last upper cheektooth measured at the cingulum |
| LLTR | greatest length of lower toothrows, from the lower canine to the last lower cheektooth measured at the cingulum |
| $M^3$-$M^3$ | greatest distance from the labial side of the cingulum of one upper $M^3$ to the labial side of the cingulum of the other $M^3$ |
| PAL/LUTR | measured only in *Rhinolophus*; the length of the palate expressed as a percentage of the length of the upper toothrow (LUTR) |
| UPMOLS | length of upper molariform toothrow |

### Locality Information

In Stanley et al. (this volume), we present detailed information on the different sites visited in the East and West Usambara Mountains. Here, we employ the site names mentioned in Stanley et al. (this volume), where details on the coordinates and elevations of the different surveyed sites can be found. Furthermore, information is repeated in the species accounts under the subheading "Specimens Examined", and the cited locality information is as originally inscribed in the field collector's catalog.

## Results

Based on our morphological examination of the specimens collected, including comparisons to previously identified voucher specimens, no evidence was found that any of the bats obtained represent an undescribed taxon. However, undescribed cryptic species may be represented in the collection, particularly in genera such as *Rhinolophus* or *Pipistrellus*. Our chiropterological surveys of the South Pare, East Usambara, and West Usambara massifs provide new information on the locally occurring species, patterns of elevational variation, and insights into numerous aspects of their natural history.

### South Pare Mountains

In the South Pare Mountains, 67 individual bats representing six species were collected during the two surveys: 62 bats of six species at 1100 m and five bats representing two species at 2000 m (Table 1), with six and two nights at each site (respectively) devoted to bat capture. Of the species obtained, the most numerous were *Lissonycteris angolensis* and *Rousettus lanosus*. At the 1100-m site, the net set that resulted in the highest capture rate was placed on an 18-m-long bridge spanning and approximately 6 m above the Mhokeveta River. At this site, relatively lush closed forest vegetation covered both banks, which created a tunnel-like overhang over the river and a natural flyway.

On several occasions, we found different bat taxa in the net at the same time, which had flown into the device from different directions. For example, on one night, 26 fruit bats were netted, consisting of 11 *L. angolensis* (seven females and four males) and 15 *R. lanosus* (12 females and three males). Although the synchronization of these captures may have been, in part, by chance, we suspect the alarm or distress calls of trapped individuals attracted other bats to the immediate vicinity that were then captured in the net. On several occasions we observed pteropodid bats tangled in the net and vocalizing, and almost immediately thereafter other fruit bats, sometimes of different genera, flew into the same net. For example, on 20 July 1993, at approximately 2000 h, a trapped *L. angolensis* vocalized and immediately singletons of *L. angolensis* and *Epomorphorus wahlbergi* flew into the net.

### Usambara Mountains

In the Usambara Mountains, 161 individual bats representing 19 species were documented during the three years of the survey between 1991 and 1993. In the East and West Usambara Mountains, 16 and 11 species, respectively, were recorded (Table 1). Most of these animals were taken at sites outside or near the edge of forested habitats. Habitat settings in which bats were netted include next to reservoirs and cisterns, across small streams and marshy areas, ecotones between forest and agricultural areas, and inside forests.

## Accounts of Species

The following accounts present information pertaining to the distribution, habitat, ecology, reproduction, specimens examined (including catalogue numbers, sites, and dates specimens were collected; see Stanley et al., this volume), and, when necessary, miscellaneous remarks.

### Family Pteropodidae
### *Epomophorus wahlbergi* (Sundevall, 1846)

Distribution—*Epomophorus wahlbergi* is distributed throughout sub-Saharan Africa, including much of Tanzania, although most records with associated vouchers are from the eastern half of the country. Bergmans (1988) cited specimens from Ambangulu, West Usambara. He also listed Amani, East Usambara, as a published locality but did not examine specimens from this site. We captured one adult specimen of *E. wahlbergi* in the South Pare Mountains, four at Ambangulu, and 23 at Amani.

Ecology and Reproduction—In the South Pare Mountains, one female was netted on 20 July 1993 over a small side channel of the Mhokevuta River in a zone where the river width was about 8 m. This specimen seemed to be attracted to the net by a vocalizing *Lissonycteris angolensis* that was already entangled. The *E. wahlbergi* specimen had large nipples, a perforate vagina, and an open pubic symphysis and was pregnant with one embryo in the right uterine horn with a crown–rump length of 17 mm.

The specimens collected in the East Usambara (EU) were taken in a variety of habitats, including at or just inside the forest edge, near standing water, and near tea plantations (see Stanley et al., this volume, for further details on the sites listed under "Specimens Examined"). Five animals (two females, three males) were netted in the ecotone between the control fragment and a tea plantation in a net set across a stream, one female was obtained at the edge of the Monga reservoir in a tea plantation, and one male was collected at a similar reservoir setting near Bulwa. Other sites where this species was collected include over a small cistern, with an opening measuring roughly 3 by 2 m, next to the Bulwa 2.6-ha fragment (one female); over a stream emerging from a marshy area near the village of Mbomole (one female, three males); and on the crest of a dam embankment next to a pond measuring approximately 40 by 80 m that was clogged with aquatic vegetation (three females, three males in 1992; two females, one male in 1993). Only two *E. wahlbergi* were captured inside natural forest, both in bird nets—one female in the 2.6-ha Bulwa fragment and one female near the start of the net line in the EU control site.

Eight female specimens from East Usambara from 1992 and 1993 were examined for reproductive activity, with four being pregnant and, in each case, with a single embryo. In three individuals, the embryo was in the left uterine horn and in one case in the right. The mean crown–rump length of the four embryos was 28.2 mm (SD = 5.4). In 1992, all pregnant specimens were captured between 30 July and 10 August, and in 1993, one pregnant female was collected on 2 August.

Two males and two females were obtained in the West Usambara (WU) during our study. One adult male was trapped in 1991 in the 5.5-ha fragment in a bird net about 1.5 m off the ground and about 25 m from the forest edge. The bat had abdominal testes measuring 6 by 4 mm, with non-convoluted epididymides. In 1992, three adult specimens were obtained in the control site—a male and a female collected at the forest edge and over a small shallow stream flowing out of the forest, and one female in a bird net in the WU control area. The male had testes measuring 7 by 6 mm with non-convoluted epididymides. One female had a slightly open pubic symphysis; the other had a closed symphysis. The nipples of both females were small.

In 1992, a female was netted between 1830 and 1950 h at the edge of a dammed pond in an agricultural area next to the village of Kazita within the Bulwa Tea Estate; other bats captured within an hour by the same net include *Rhinolophus fumigatus*, *Neoromicia nanus*, *Pipistrellus hesperidus*, and *Scotophilus dinganii*.

Comments—A one-way ANOVA was conducted on forearm length and the greatest length of skull to determine if size between the sexes was measurably different. Both measurements were significant (forearm length: F = 13.4, P = 0.003; skull length: F = 20.0, P = 0.003). Hence, descriptive statistics derived from external and cranio-dental measurements for each sex are presented separately (Tables 2 and 3).

Based on palatal ridge morphology, maxillary shape, and certain external measurements (Taylor & Monadjem, 2008; Monadjem et al., 2010), no evidence of *E. labiatus* or *E. crypturus* was found in the samples. *Epomophorus labiatus* is known from localities in northwestern and southwestern Tanzania, and *E. crypturus* from the southern portion of the country, but neither has been documented in northeastern Tanzania or the Eastern Arc Mountains (Bergmans, 1988).

Specimens Examined—**EAST USAMBARA**, 4.5 km ESE Amani, Monga Tea Estate, EU control site, 16–23 August 1992 (FMNH 150048–150050, 150397, 150398); 4.5 km WNW Amani, Monga Tea Estate, EU control site, 4–5 August 1992, 2–5 August 1993 (FMNH 150041, 150044, 150045, 150390–150396, 151179, 151180, 151413); 6 km NW Amani, Monga Tea Estate, 30 July 1992 (FMNH 150043); 8 km NWN Amani, Bulwa Tea Estate, 9–10 August 1992 (FMNH 150042, 150046, 150047); **WEST USAMBARA**, 11 km NW Korogwe, Ambangulu Tea Estate, 28 July 1991 (FMNH 147215); 12.5 km NW Korogwe, Ambangulu Tea Estate, WU control site, 1–2 September 1992 (FMNH 150399, 150400, 150051); **SOUTH PARE**, Chome Forest Reserve, 7 km S Bombo, 20 July 1993 (FMNH 151182).

### *Lissonycteris angolensis* (Bocage, 1898)

Distribution—Bergmans (1994) recognized five subspecies of *Lissonycteris angolensis* distributed across western, central, and eastern Africa, and assigned specimens from eastern Africa to *L. a. ruwenzorii*, citing specimens from both Amani and Kwamkoro in the East Usambara. Simmons (2005) suggested that the *L. angolensis* complex may contain more

TABLE 2. External measurements (mm) and weight (g) of fruit bats (Pteropodidae) collected during 1991–1994 surveys of the East Usambara (EU), West Usambara (WU), and South Pare (SP) Mountains. Measurements were taken by both S.M.G. and W.T.S.

| Species | TL | HB | TV | HF | EAR | FA | WT |
|---|---|---|---|---|---|---|---|
| *Epomophorus wahlbergi* W.T.S. | | | | | | | |
| ♀ EU | | | | | | | |
| Mean ± SD | 150.0 ± 1.41 | 146.0 ± 1.41 | 5.0 ± 1.41 | 21.0 ± 0.00 | 24.0 ± 1.41 | 83.5 ± 2.12 | 85.5 ± 13.44 |
| Range | 149–151 | 145–147 | 4–6 | 21–21 | 23–25 | 82–85 | 76–95 |
| n | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| ♂ EU | | | | | | | |
| Mean ± SD | 157.3 ± 11.87 | 150.8 ± 10.05 | 5.3 ± 0.50 | 23.3 ± 0.96 | 24.8 ± 0.50 | 84.5 ± 4.43 | 98.8 ± 16.68 |
| Range | 142–170 | 137–160 | 5–6 | 22–24 | 24–25 | 79–89 | 75–114 |
| n | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| *Epomophorus wahlbergi* S.M.G. | | | | | | | |
| ♀ EU, WU, SP | | | | | | | |
| Mean ± SD | 159.9 ± 4.58 | 157.0 ± 7.30 | 5.0 | 17.2 ± 0.70 | 24.9 ± 1.49 | 82.6 ± 1.98 | 88.5 ± 6.25 |
| Range | 150–166 | 149–165 | | 16–19 | 22–27 | 78–85 | 76.5–97 |
| n | 10 | 4 | 1 | 14 | 14 | 14 | 14 |
| ♂ EU, WU | | | | | | | |
| Mean ± SD | 174.8 ± 5.72 | 175.3 ± 7.51 | | 18.6 ± 2.33 | 25.5 ± 1.20 | 86.0 ± 1.07 | 108.2 ± 8.93 |
| Range | 170–184 | 168–183 | | 17–24 | 23–27 | 85–88 | 99.5–128 |
| n | 5 | 3 | | 8 | 8 | 8 | 8 |
| *Lissonycteris angolensis* ♀, ♂, EU, WU, SP | | | | | | | |
| W.T.S. | | | | | | | |
| Mean ± SD | 135.8 ± 4.69 | 129.0 ± 3.46 | 8.5 ± 1.58 | 22.1 ± 1.73 | 24.2 ± 0.92 | 81.3 ± 1.77 | 73.8 ± 6.25 |
| Range | 130–145 | 125–135 | 5–10 | 20–24 | 22–25 | 79–84 | 64.5–86 |
| n | 10 | 7 | 10 | 10 | 10 | 10 | 10 |
| S.M.G. | | | | | | | |
| Mean ± SD | 143.5 ± 4.42 | 134 | 8.6 ± 1.95 | 18.2 ± 1.75 | 24.0 ± 1.05 | 81.1 ± 3.09 | 73.5 ± 6.99 |
| Range | 131–153 | | 3–14 | 13–24 | 22–26 | 75–89 | 62–93 |
| n | 48 | 1 | 47 | 48 | 48 | 48 | 48 |
| *Myonycteris relicta* ♀ WU | | | | | | | |
| S.M.G. | | | | | | | |
| Mean ± SD | 130.5 ± 0.71 | | 11.5 ± 0.71 | 17.0 ± 0.00 | 22.0 ± 0.00 | 72.0 ± 0.00 | 58.3 ± 3.18 |
| Range | 130–131 | | 11–12 | 17–17 | 22–22 | 72–72 | 56–60.5 |
| n | 2 | | 2 | 2 | 2 | 2 | 2 |
| W.T.S. | 127 | 117 | 10 | 18 | 21 | 75 | 56 |
| *Rousettus aegyptiacus* S.M.G. | | | | | | | |
| ♀ EU | 147 | | 15 | 17 | 23 | 92 | 94.5 |
| ♂ EU | | | | | | | |
| Mean ± SD | 174.0 ± 4.58 | | 11.0 ± 3.46 | 19.0 ± 1.00 | 24.0 ± 2.00 | 96.0 ± 2.65 | 142.7 ± 8.39 |
| Range | 169–178 | | 9–15 | 18–20 | 22–26 | 94–99 | 133–148 |
| n | 3 | | 3 | 3 | 3 | 3 | 3 |
| *Rousettus aegyptiacus* W.T.S. | | | | | | | |
| ♀ EU | 158 | 140 | 15 | 25 | 22 | 95 | 97 |
| *Rousettus lanosus* S.M.G. | | | | | | | |
| ♀ Mean ± SD | 163.2 ± 7.66 | | 18.5 ± 1.44 | 18.4 ± 1.16 | 23.4 ± 1.31 | 90.7 ± 2.90 | 114.8 ± 12.02 |
| Range | 151–176 | | 17–22 | 16–20 | 21–25 | 86–95 | 97–132 |
| n | 12 | | 12 | 12 | 12 | 12 | 10 |
| ♂ Mean ± SD | 164.7 ± 3.79 | | 17.7 ± 1.53 | 19.0 ± 1.00 | 24.3 ± 2.08 | 93.0 ± 1.73 | 127.7 ± 5.03 |
| Range | 162–169 | | 16–19 | 18–20 | 22–26 | 92–95 | 123–133 |
| n | 3 | | 3 | 3 | 3 | 3 | 3 |
| *Rousettus lanosus* W.T.S. | | | | | | | |
| ♀ | 151 | 138 | 18 | 23 | 24 | 86 | 89 |

than one species, and at least one of these subspecies has been elevated to full species (*L. goliath*) by Monadjem et al. (2010).

ECOLOGY AND REPRODUCTION—Twelve (11 females and one male) and 20 (nine females and 11 males) specimens, were collected in the East and West Usambara Mountains, respectively. Nine females were examined for embryos; four collected 23 July 1991 and between 26 July and 2 September were not in active reproduction, and five collected 1 July 1991 and between 25 July and 5 August 1992 had one embryo each, with a mean crown–rump length (SD, range) of 4.8 mm (0.84, 4–6, n = 5). The six males examined for reproductive status had mean testes measurements of 7.3 mm (1.03, 6–9) by 4.8 mm (0.98, 4–6). The epididymides of three males collected in July 1991, July 1992, and August 1993 were convoluted, whereas the three other males obtained in July 1991 and August 1992 were not convoluted.

In the South Pare Mountains, 28 specimens were netted during the two surveys: 26 (nine males and 17 females) at

TABLE 3. Cranio-dental measurements of fruit bats (Pteropodidae) from both the East and West Usambaras.

| Measurement | *Epomophorus wahlbergi* ♀ (n = 8) | *Epomophorus wahlbergi* ♂ (n = 5) | *Lissonycteris angolensis* ♀ (n = 8) | *Lissonycteris angolensis* ♂ (n = 5) | *Myonycteris relicta* ♀ (n = 3)[1] | *Rousettus aegyptiacus* ♀ (n = 2) | *Rousettus aegyptiacus* ♂ (n = 2) | *Rousettus lanosus* ♀ (n = 6) | *Rousettus lanosus* ♂ (n = 1) |
|---|---|---|---|---|---|---|---|---|---|
| CRN | | | | | | | | | |
| Mean ± SD | 47.5 ± 1.59 | 51.6 ± 0.55 | 40.5 ± 0.86 | 40.5 ± 1.08 | 36.0 ± 0.40 | 40.8 ± 0.95 | 43.0 ± 0.67 | 41.8 ± 0.99 | |
| Range | 45.1–49.6 | 50.8–52.3 | 39.0–41.7 | 39.4–42.0 | 35.8–36.5 | 40.2–41.5 | 42.5–43.5 | 40.3–42.9 | |
| CBL | | | | | | | | | |
| Mean ± SD | 47.5 ± 1.59 | 51.6 ± 0.55 | 39.8 ± 0.77 | 40.0 ± 0.94 | 35.0 ± 0.40 | 39.7 ± 0.23 | 41.8 ± 0.62 | 40.0 ± 0.95 | |
| Range | 45.1–49.6 | 50.8–52.3 | 38.3–40.5 | 38.9–41.2 | 34.7–35.5 | 39.6–39.9 | 41.4–42.3 | 38.6–41.1 | |
| ROST | | | | | | | | | |
| Mean ± SD | 19.2 ± 1.05 | 21.0 ± 0.30 | 15.2 ± 0.45 | 15.1 ± 0.32 | 13.0 ± 0.25 | 15.4 ± 0.42 | 16.6 ± 0.47 | 16.8 ± 0.33 | |
| Range | 18.0–20.7 | 20.6–21.3 | 14.6–15.8 | 14.7–15.4 | 12.8–13.2 | 15.1–15.7 | 16.3–17.0 | 16.4–17.2 | |
| PAL | | | | | | | | | |
| Mean ± SD | 28.3 ± 1.11 | 30.7 ± 0.54 | 22.5 ± 0.32 | 22.5 ± 0.29 | 19.1 ± 0.55 | 22.6 ± 0.04 | 24.1 ± 0.69 | 21.8 ± 0.46 | |
| Range | 26.9–29.9 | 30.0–31.5 | 22.0–22.9 | 22.1–22.9 | 18.7–19.7 | 22.6–22.6 | 23.6–24.6 | 21.2–22.4 | |
| BW | | | | | | | | | |
| Mean ± SD | 16.9 ± 0.33 | 17.4 ± 0.18 | 15.8 ± 0.34 | 15.6 ± 0.38 | 14.9 ± 0.28 | 16.2 ± 0.66 | 17.5 ± 0.17 | 17.0 ± 0.38 | 16.8 |
| Range | 16.5–17.3 | 17.2–17.7 | 15.3–16.4 | 15.3–16.2 | 14.6–15.2 | 15.8–16.7 | 17.4–17.6 | 16.4–17.5 | |
| IOW | | | | | | | | | |
| Mean ± SD | 8.3 ± 0.29 | 9.1 ± 0.48 | 7.3 ± 0.20 | 7.1 ± 0.49 | 7.1 ± 0.11 | 8.1 ± 0.39 | 8.8 ± 0.11 | 7.7 ± 0.22 | 7.8 |
| Range | 7.7–8.7 | 8.2–9.6 | 7.0–7.5 | 6.4–7.7 | 6.9–7.2 | 7.8–8.3 | 8.7–8.9 | 7.5–8.1 | |
| POW | | | | | | | | | |
| Mean ± SD | 9.8 ± 0.52 | 9.9 ± 0.67 | 8.9 ± 0.69 | 8.5 ± 0.27 | 9.2 ± 0.68 | 8.6 ± 0.57 | 8.2 ± 0.45 | 9.8 ± 0.58 | 9.7 |
| Range | 9.0–10.3 | 8.9–10.7 | 7.9–10.1 | 8.2–8.9 | 8.7–10.0 | 8.2–9.0 | 7.9–8.5 | 8.9-10.5 | |
| ZYG | | | | | | | | | |
| Mean ± SD | 25.9 ± 0.56 | 27.5 ± 0.44 | 23.9 ± 0.72 | 24.0 ± 0.59 | 22.0 ± 0.05 | 23.5 ± 0.73 | 27.9 ± 0.62 | 24.0 ± 0.88 | 24.7 |
| Range | 25.1–26.6 | 27.1–28.1 | 22.5–24.7 | 23.1–24.6 | 21.9–22.0 | 22.9–24.0 | 27.5–28.3 | 22.5–25.0 | |
| MAND con | | | | | | | | | |
| Mean ± SD | 37.3 ± 1.08 | 41.2 ± 0.79 | 31.8 ± 0.67 | 31.6 ± 0.57 | 27.7 ± 0.40 | 32.5 ± 0.68 | 34.0 ± 0.12 | 32.5 ± 0.82 | 32.4 |
| Range | 35.8–39.2 | 40.4–42.4 | 30.9–32.6 | 31.0–32.5 | 27.4–28.2 | 32.0–32.9 | 34.0–34.1 | 31.6–33.6 | |
| MAND ang | | | | | | | | | |
| Mean ± SD | 36.3 ± 1.41 | 39.6 ± 0.87 | 30.3 ± 0.52 | 29.8 ± 0.51 | 26.2 ± 0.24 | 31.2 ± 1.08 | 32.4 ± 0.37 | 30.6 ± 0.84 | 30.3 |
| Range | 34.4–38.6 | 38.9–41.1 | 29.4–30.9 | 29.3–30.6 | 26.0–26.5 | 30.4–32.0 | 32.2–32.7 | 29.4–31.7 | |
| MAND HT | | | | | | | | | |
| Mean ± SD | 15.5 ± 0.43 | 17.3 ± 0.75 | 13.1 ± 0.65 | 13.3 ± 0.43 | 11.1 ± 0.48 | 12.1 ± 0.93 | 14.3 ± 0.23 | 11.8 ± 1.00 | 11.8 |
| Range | 14.9–16.2 | 16.5–18.1 | 12.2–14.1 | 12.7–13.9 | 10.7–11.6 | 11.5–12.8 | 14.1–14.4 | 9.9–12.7 | |
| LUTR | | | | | | | | | |
| Mean ± SD | 16.4 ± 0.54 | 17.8 ± 0.36 | 15.5 ± 0.49 | 15.6 ± 0.28 | 13.5 ± 0.32 | 15.7 ± 0.55 | 16.8 ± 0.03 | 14.7 ± 0.31 | |
| Range | 15.3–17.2 | 17.3–18.2 | 14.7–16.3 | 15.1–15.9 | 13.1–13.7 | 15.3–16.1 | 16.8–16.8 | 14.3–15.2 | |
| C-C cing | | | | | | | | | |
| Mean ± SD | 9.4 ± 0.28 | 10.5 ± 0.28 | 7.9 ± 0.26 | 7.7 ± 0.19 | 7.0 ± 0.15 | 8.0 ± 0.06 | 9.3 ± 0.30 | 8.7 ± 0.29 | |
| Range | 9.0–9.8 | 10.2–10.9 | 7.4–8.2 | 7.4–8.0 | 6.9–7.2 | 7.9–8.0 | 9.1–9.5 | 8.2–9.0 | |
| C-C alv | | | | | | | | | |
| Mean ± SD | 8.8 ± 0.29 | 9.9 ± 0.29 | 7.0 ± 0.19 | 6.9 ± 0.18 | 6.3 ± 0.03 | 7.3 ± 0.36 | 8.5 ± 0.27 | 8.2 ± 0.22 | |
| Range | 8.5–9.3 | 9.5–10.2 | 6.6–7.3 | 6.7–7.2 | 6.3–6.4 | 7.0–7.5 | 8.3–8.7 | 7.8–8.4 | |
| LLTR | | | | | | | | | |
| Mean ± SD | 18.3 ± 0.74 | 20.1 ± 0.52 | 16.9 ± 0.38 | 17.1 ± 0.32 | 13.3 ± 0.26 | 17.1 ± 0.73 | 18.4 ± 0.03 | 16.5 ± 0.43 | |
| Range | 17.3–19.8 | 19.4–20.8 | 16.2–17.3 | 16.8–17.5 | 13.1–13.6 | 16.6–17.6 | 18.4–18.4 | 16.0–17.2 | |

[1] For ZYG measurements of *M. relicta*, n = 2.

1100 m and two females at 2000 m. Of the eight females examined for reproductive status, seven were pregnant, all with one embryo in the oviduct: four in the right horn and three in the left horn. The six pregnant females collected at 1100 m between 18 and 23 July 1993 had mean embryo lengths of 5.5 mm (0.84, 4–6). One pregnant female was collected at 2000 m on 25 August 1994 with a single embryo measuring 20 mm in crown–rump length. Ten of the female specimens collected in July 1993 had open pelvic symphyses.

The nine male *L. angolensis* collected at the 1100-m site in the South Pare Mountains all had abdominal testes. The sexual organs of four animals were measured, with the testes length ranging from 3 to 8 mm and width from 2 to 6 mm; only one of the four had convoluted epididymides.

COMMENTS—Bergmans (1997) concluded that male *L. angolensis* skulls are slightly larger than females, whereas females have slightly longer forearms than males. A one-way ANOVA was conducted to test for significant differences in cranio-dental measurements between sexes and samples from our East and West Usambara collections (only females were collected in the East Usambara). In contrast to the results of Bergmans (1997), not one of the cranio-dental measurements ($P \leq 0.05$) or forearm length ($F = 0.98$, $P = 0.33$; females = 79.4, males = 78.3) showed a significant difference between the sexes or populations from the Usambara Massifs. Hence, samples from both mountains and sexes are combined for external measurements (but presented separately for each collector; Table 2) and for the cranio-dental measurements (Table 3).

*Lissonycteris* can be differentiated from *Rousettus* by the presence of webbing between the toes, a collar of thick rough hair around the neck and chest in males, and a weak angle in the alveolar line between the third and fourth premolar (Bergmans, 1997).

Specimens Examined—**EAST USAMBARA**, 6 km NW Amani, Monga Tea Estate, 25–27 July 1992 (FMNH 150055–150057, 150059, 150402, 150403); 4.5 km WNW Amani, Monga Tea Estate, EU control site, 5 August 1992, 19 August 1993 (FMNH 150060–150062, 150404, 150405, 151388); **WEST USAMBARA**, 14.5 km NW Korogwe, Ambangulu Tea Estate, 23 July 1991, 29 August–2 September 1992, 19 August 1993 (FMNH 147219); 12.5 km NW Korogwe, Ambangulu Tea Estate, WU control site, 1–13 July 1991, 29 August–3 September 1992, 19 August 1993 (FMNH 147216–147218, 147377–147380, 147383–147385, 150058, 150063, 150064, 150401, 150406, 150407, 151159); **SOUTH PARE**, Chome Forest Reserve, 7 km S Bombo, 1100 m, 18–23 July 1993 (FMNH 151160–151170, 151389–151403); Chome Forest Reserve, 3 km E, 0.7 km N Mhero, 2000 m, 25–26 August 1994 (FMNH 153845, 153925).

### *Myonycteris relicta* Bergmans, 1980

Distribution—This species was described by Bergmans (1980) based on a holotype from the Shimba Hills in Kenya, roughly 100 km from the eastern edge of the East Usambara, and the paratypes collected at Ambangulu in January 1900. Subsequent records from Tanzania include the Nguru Mountains in 1960 (Schlitter & McLaren, 1981), the Udzungwa Mountains in 1995 (Stanley et al., 2005b), and the East Usambara in Mgambo Forest Reserve at 400 m by N. J. Cordeiro (FMNH 163391) in 1996. During our field research, three adult females were captured at the control site in the West Usambara Mountains.

Ecology and Reproduction—Two females were captured in 1991 over a small stream flowing out of the WU control site. Both of these were found tangled in the net during the pre-dawn check and had large teats but were not lactating. The third specimen was captured in a furled bird net within the WU control site forest in 1993. This female had an open pubic symphysis and large teats but was not lactating. Both external (Table 2) and cranio-dental (Table 3) measurements fall within the range provided by Bergmans (1997) for this species.

Specimens Examined—**WEST USAMBARA**, 12.5 km NW Korogwe, Ambangulu Tea Estate, WU control site, 5 July 1991, 18 August 1993 (FMNH 147381, 147382, 151404).

### *Rousettus aegyptiacus* (É. Geoffroy Sainte-Hilaire, 1810)

Distribution—*Rousettus aegyptiacus* is broadly distributed across Africa, particularly in coastal and lowland habitats, but largely unknown from montane settings within Tanzania (Bergmans, 1994; Stanley et al., 2005b, 2007a). Two geographically distinct subspecies have been recognized in sub-Saharan Africa (Bergmans, 1994), with *R. a. leachii* occurring in the eastern portion of this zone. This species was not captured during our surveys of the South Pare or West Usambara Mountains.

Ecology and Reproduction—In the East Usambara, five adults (four in 1992, one in 1993) were obtained, including two (one male in 1992 and one female in 1993) collected in a net set over a dam reservoir, one male at the edge of an open well cistern next to the 2.6-ha Bulwa fragment, and one female and one male over a stream in the ecotone between forest and tea plantation.

The three males collected in the first half of August 1992 were all scrotal. Two were dissected to assess reproductive status, of which one had testes measuring 15 by 10 mm and the other 17 by 12 mm, both with convoluted epididymides. The two captured females (collected in the first half of August in both 1992 and 1993) were pregnant—each carrying a single embryo, the largest with a crown–rump length of 7 mm.

Comments—Three males and two females were collected at sites in the East Usambara; the sample is too small to test for sexual dimorphism. However, based on the external and cranio-dental measurements presented by Bergmans (1994) and Kwiecinski and Griffiths (1999), females are smaller on average than males.

See the *Lissonycteris* account for characters to differentiate this genus from *Rousettus*. *Rousettus aegyptiacus* can be differentiated from *R. lanosus* by the presence of more rounded upper cheekteeth and very short, thin fur on the back. *Rousettus lanosus* has very narrow cheekteeth and thick fur.

Specimens Examined—**EAST USAMBARA**, 4.5 km WNW Amani, Monga Tea Estate, EU control site, 5 August 1992, 2 August 1993 (FMNH 150052, 151158); 4.5 km ESE Amani, Monga Tea Estate, EU control site, 14–16 August 1992 (FMNH 150054, 150408); 8 km NWN Amani, Bulwa Tea Estate, 12 August 1992 (FMNH 150053).

### *Rousettus lanosus* Thomas 1906

Distribution—*Rousettus lanosus* is restricted to montane habitats in eastern and central Africa, including Democratic Republic of the Congo, Ethiopia, Kenya, Malawi, Uganda, and Tanzania (Bergmans, 1994; Simmons, 2005). Within Tanzania, this species has been documented on the mountains of Ngorongoro, Hanang, Kilimanjaro, West Usambara (at Isongo), Uluguru, and Mahenge (Bergmans, 1994). Based on the distribution of voucher material from montane zones in eastern Tanzania, Bergmans (1994) suggested that *R. lanosus* occurs in the "Para" range, which we assume is meant to be the Pares. No specimen of *R. lanosus* was collected during our surveys of the East or West Usambara Mountains, although Rodgers and Homewood (1982) list this species as occurring in the West Usambara.

Ecology and Reproduction—*Rousettus lanosus* was found in the South Pare Mountains and was the second most commonly captured bat at 1100 m (three males and 13 females) but was not found at 2000 m. Seven of the females captured between 19 and 24 July 1993 were examined for reproductive status and five were pregnant, all with single embryos—two with the embryos in the left uterine horn and three with the embryos in the right horn. The crown–rump length of the embryos was on average 17.8 mm (7.6, 7–27 mm; four of the five individuals had embryos of 14 mm crown–rump length or greater); these measures are notably larger than the embryos for *L. angolensis* from the same site and period. Body weight differed considerably, reflecting the difference between pregnant and non-pregnant individuals (Table 2). All three males obtained in the South Pare Mountains had scrotal testes. The one specimen examined had testes measuring 10 by 5 mm with convoluted epididymides. External and cranio-dental measurements for each sex and field collector are presented in Tables 2 and 3.

Specimens Examined—**SOUTH PARE**, Chome Forest Reserve, 7 km S Bombo, 1100 m, 19–24 July 1993 (FMNH 151171–151178, 151405–151412).

**Family Rhinolophidae**
***Rhinolophus clivosus* Cretzschmar, 1828**

Distribution—*Rhinolophus clivosus* is widespread across the African continent from South Africa north to Egypt and then eastward to the Arabian Peninsula. Although mainly a savannah woodland species, it has been found at elevations up to 2300 m (Ansell & Dowsett, 1988) and is known from forest fringes. In Tanzania, this species has been documented from Kilimanjaro, Udzungwa, and Nguru Mountains (Csorba et al., 2003; W. T. Stanley, unpubl. data).

Ecology and Reproduction—In the East Usambara, five females and seven males were collected, of which nine were taken in intact montane forest and three in degraded forest mixed with *Maesopsis* trees. Most individuals were captured between 1830 and 1900 h. Of the four females examined, two (collected 17 August 1992) had small teats and two had large, non-lactating teats (collected during the first half of August in 1991 and 1993). Of the six males examined within the first half of August 1991, 1992, and 1993, three were scrotal and three had abdominal testes, one of which had testes that measured 4 by 3 mm with non-convoluted epididymides.

In the West Usambara, six females and nine males were collected. In 1991, two of these specimens were captured in bird nets placed within the control site in an area of largely primary forest, but with pockets of secondary habitat; the bats were netted in secondary habitat. Furthermore, two individuals were obtained in the 40-ha fragment forest, one in the 1.9-ha fragment, and another in a stand of *Eucalyptus* trees. In 1992, specimens were trapped in bird nets within the forest set at distances of 67.5 to 324 m to the edge. Two females were dissected: one was not in a reproductive state and the other had an embryo that measured 10 mm in crown–rump length. Four of the males collected between July and September 1991, 1992, and 1993 were scrotal, one of which measured 3 by 2 mm and had convoluted epididymides; the other five had abdominal testes.

In the South Pare Mountains, we caught three females and two males at 1100 m and one individual of each sex at 2000 m. The two males trapped at 1100 m had abdominal testes, but the male from 2000 m was partially scrotal. Two of three females collected at 1100 m had small teats; the third had large teats but was not lactating.

Comments—A one-way ANOVA test to assess levels of sexual dimorphism in external measurements in the East Usambara specimens revealed no significant differences. Among external measurements of West Usambara animals, weight was the only variable that differed significantly between the sexes, with females being heavier than males (female mean = 18.4, male mean = 15.5; F = 20.9, P = 0.001); this difference is associated with the additional weight of embryos in pregnant females.

Two of six females collected were examined for embryos; one was not pregnant (weight 15 g) and another had a single fetus that measured 10 mm in crown–rump length (weight 18.5 g). A one-way ANOVA to assess differences between the East and West Usambara samples (measured by S.M.G.) showed that *R. clivosus* from East Usambara had shorter hind feet and forearms than those from the West (Table 4). External measurements are presented for each field collector and mountain, but sexes are combined (Table 4).

Among cranio-dental characters, the three male animals from the West Usambara exhibited significantly longer length of the toothrow measured at the cingulum (LUTR) compared with two females (female mean = 8.3, male mean = 8.5; F = 28.1, P = 0.01). However, the same comparison for the three males and two females from the East Usambara showed no significant difference in this variable (female mean = 8.3, male mean = 8.3; F = 0.001, P = 0.97). When the samples from both mountains are combined and the sexes compared, there are no significant differences (female mean = 8.3, male mean = 8.4; F = 1.5, P = 0.25). Given the small sample sizes and that no other character exhibited sexual dimorphism, we do not attribute biological importance to this result. We combine the sexes and localities for the cranio-dental measurements in Table 5.

*Rhinolophus clivosus* has a high, rounded connecting process, and the first upper premolar is completely outside the toothrow. The rostral profile is nearly horizontal because of the reduced anterior median swellings (Csorba et al., 2003).

Specimens Examined—**EAST USAMBARA**, 4.5 km ESE Amani, Monga Tea Estate, EU control site, 17 August 1992, 7–8 August 1993 (FMNH 150071, 150410, 151192, 151419, 151420); 4.5 km WNW Amani, Monga Tea Estate, EU control site, 5–9 August 1991, 2–4 August 1992, 1 August 1993 (FMNH 147225, 147395–147397, 150066, 150070, 151418); **WEST USAMBARA**, 14.5 km NW Korogwe, Ambangulu Tea Estate, 20 July 1991 (FMNH 147392, 147393); 12.5 km NW Korogwe, Ambangulu Tea Estate, WU control site, 3–13 July 1991, 29 August–2 September 1992 (FMNH 147222, 147223, 147388–147391, 150068, 150069, 150411–150413); 11 km NW Korogwe, Ambangulu Tea Estate, 28–29 July 1991 (FMNH 147224, 147394); **SOUTH PARE**, Chome Forest Reserve, 7 km S Bombo, 1100 m, 18–20 July 1993 (FMNH 151193, 151194, 151423–151425); Chome Forest Reserve, 3 km E, 0.7 km N Mhero, 2000 m, 27 August 1994 (FMNH 153848, 153849).

***Rhinolophus deckenii* Peters, 1867**

Distribution—*Rhinolophus deckenii* is restricted to southeastern Kenya, Uganda, eastern Tanzania (where collection localities include coastal forests and some Eastern Arc Mountains), and Mozambique (Monadjem et al., 2010). Stanley et al. (2005a) recorded *R. deckenii* from the Malundwe Mountains at 900 m in Mikumi National Park in dry submontane forest. This species was not captured in the South Pare or West Usambara Mountains.

Ecology and Reproduction—In the East Usambara, one scrotal male of *R. deckenii* was collected soon after dusk in slightly degraded montane forest in a bird net placed in the northeastern portion of the EU control site. Stanley et al. (2005a) found two color morphs in the Malundwe Mountains (cinnamon-brown and dull brown), as has been previously documented (Csorba et al., 2003). The specimen collected in the East Usambara was dull brown.

Comments—*Rhinolophus deckenii* has a wide horseshoe (>9 mm) and a semicircular connecting process, and the upper canine and posterior upper premolar are separated by a narrow gap (Csorba et al., 2003).

Specimen Examined—**EAST USAMBARA**, 4.5 km WNW Amani, Monga Tea Estate, EU control site, 5 August 1992 (FMNH 150409).

***Rhinolophus fumigatus* Rüppell, 1842**

Distribution—*Rhinolophus fumigatus* is broadly distributed across sub-Saharan Africa. In Tanzania, this species has been collected mostly in the east, including both montane and coastal forest habitats. N. J. Cordiero captured one specimen in the Mgambo Forest Reserve of the East Usambara at 400 m in 1996 (FMNH 163396). Koopman (1994) recognized the form *R. f. exsul* Anderson, 1905, as occurring in Tanzania. This species was not trapped in the South Pare or West Usambara Mountains during our study.

Ecology and Reproduction—In the East Usambara, one female was obtained in August 1992 that had single embryos in each uterine horn, the largest of which was 4 mm in crown–rump length. Csorba et al. (2003) mentioned that this species is not found in forest habitat, but on the fringes, and Monadjem et al. (2010) considered it a savanna woodland species. Our East Usambara animal was netted at the edge of a dammed pond in an agricultural area. Other species captured in the same set and within one hour of the individual *R. fumigatus* include *Epomophorus wahlbergi*, *Neoromicia nanus*, *Pipistrellus hesperidus*, and *Scotophilus dinganii*.

Comments—*Rhinolophus fumigatus* has a wide horseshoe (>9 mm) and a low connecting process, and the upper canine and posterior upper premolar widely overlap each other (Csorba et al., 2003).

Specimen Examined—**EAST USAMBARA**, 8 km NWN Amani, Bulwa Tea Estate, 10 August 1992 (FMNH 150067).

***Rhinolophus hildebrandti* Peters, 1878**

Distribution—*Rhinolophus hildebrandti* is distributed across eastern and southern Africa and is known from different localities in Tanzania, including the Udzungwa Mountains (Stanley et al., 2005b) and Gonja Forest Reserve at the base of the South Pare Mountains (Stanley et al., 2000). It was not collected on the South Pares or Tanzanian coastal forests at the base of the East Usambara Mountains (Stanley et al., 2005c).

Ecology and Reproduction—In the East Usambara Mountains, one male with abdominal testes was captured at the edge of the 2.6-ha Bulwa site near an open cistern, and two females were collected in August 1992 and 1993 near the village of Mbomole in a net set over a stream running through a marshy area. The reproductive condition of one of the two collected females was assessed, and it showed no sign of activity. In the West Usambara Mountains, one male was collected 15 July 1991 in partially cleared forest and had abdominal testes that measured 3 by 2 mm, with non-convoluted epididymides. Sexes are combined in presentation of external and cranio-dental measurements (Tables 4 and 5).

Comments—*Rhinolophus hildebrandti* is the largest known member of this genus in Tanzania, with a forearm length of greater than 60 mm and a horseshoe that is 12 mm or wider (Csorba et al., 2003).

Specimens Examined—**EAST USAMBARA**, 4.5 km WNW Amani, Monga Tea Estate, EU control site, 4 August 1992, 4 August 1993 (FMNH 150072, 151422); 8 km NWN Amani, Bulwa Tea Estate, 9 August 1992 (FMNH 150414); **WEST USAMBARA**, 12.5 km NW Korogwe, Ambangulu Tea Estate, WU control site, 15 July 1991 (FMNH 147226).

***Rhinolophus simulator* Anderson, 1904**

Distribution—*Rhinolophus simulator* has a disjunct distribution across sub-Saharan Africa, with *R. s. simulator* to the east, from South Africa to Ethiopia, and *R. s. alticolus* in western Africa, from Cameroon to Guinea (Csorba et al., 2003; Monadjem et al., 2010). In Tanzania, the nominate form has been collected across broad elevational and habitat ranges, including Rukwa in the southwest and montane settings including Rubeho, Udzungwa (Kihansi Gorge), Uluguru, and Meru (Csorba et al., 2003; N. J. Cordeiro, unpubl. data; W. T. Stanley, unpubl. data). This species was not found in the East or West Usambara Mountains during our study.

Ecology and Reproduction—In the South Pare Mountains at the 2000-m site, one female was netted over a small stream deep within the forest. This individual had no embryo or placental scar, although the right oviduct was enlarged.

Comments—*Rhinolophus simulator* has a horseshoe that is less than 8.4 mm and a rounded, well-haired connecting process, and the first upper premolar is within the toothrow (Csorba et al., 2003).

Specimen Examined—**SOUTH PARE**, Chome Forest Reserve, 3 km E, 0.7 km N Mhero, 22 August 1994 (FMNH 153928).

***Rhinolophus swinnyi* Gough, 1908**

Distribution—*Rhinolophus swinnyi* is known from the southern half of the African continent, but only a few localities in Tanzania, including the Udzungwa Mountains and Zanzibar (Kock & Howell, 1988). Although generally occurring in savanna woodland, some specimens have been collected in montane forests (Csorba et al., 2003).

Ecology and Reproduction—We only captured this species in the East Usambara Mountains, where two males and one female were collected. The female was netted adjacent to a water cistern next to the 2.6-ha Bulwa fragment and had no embryo or placental scar. One of the males was collected over a stream in the ecotone between forest and tea plantation, and the testes were partially scrotal. The other male was captured at the edge of a marsh next to the village of Mbomole and had abdominal testes.

Comments—The two male specimens were identified by the late Karl Koopman (pers. comm.) as *R. simulator*. However, we base our identification as *R. swinnyi* on characteristics listed by Csorba et al. (2003), namely narrow horseshoe and sella and short ear length.

Specimens Examined—**EAST USAMBARA**, 8 km NWN Amani, Bulwa Tea Estate, 11 August 1992 (FMNH 150073); 4.5 km WNW Amani, Monga Tea Estate, EU control site, 4 August 1993 (FMNH 151421); 4.5 km ESE Amani, Monga Tea Estate, EU control site, 14 August 1992 (FMNH 150415).

**Family Nycteridae**
***Nycteris grandis* Peters, 1865**

Distribution—Both Van Cakenberghe and De Vree (1993) and Hickey and Dunlop (2000) indicate that *Nycteris grandis* shows two disjunct populations: one in west central Africa (nominate *grandis*) and the other along the eastern half of Tanzania (the form *marica*). This species is generally a humid forest animal that can also be found in gallery forests, swampy areas, and woodland habitats (Hickey & Dunlop, 2000). Our surveys documented this species only in the East Usambara Mountains.

Ecology and Reproduction—One female was collected 2 August 1992, and two females were captured 30 and 31 July 1993 at the same site in the East Usambara. All three bats were captured in a mist net set on, or near, a bridge spanning a small stream in disturbed forest with some *Maesopsis* trees and a swampy area upstream. The one female for which the sexual organs were examined and obtained on 31 July had an embryo in the left uterine horn with a crown–rump length measuring 3 mm.

Comments—Kershaw (1923) described *N. marica* from Tindiga (Tendigo), Kilosa, Tanzania, based on the smaller skull dimensions and larger fourth lower premolar, as compared with typical *N. grandis*. Kock (1981) maintained that *marica* was a valid subspecies of *grandis* and that the form in eastern Africa was morphologically distinct from those in the western and central portions of the continent. However, Van Cakenberghe and De Vree (1993) found no support for the partition of *N. grandis* into subspecies. Our measurements of forearm length fall within the range given by Van Cakenberghe and De Vree (1993; Table 4). Monadjem et al. (2010) hypothesize that these two forms may represent different evolutionary lineages separated by habitat type.

Specimens Examined—**EAST USAMBARA**, 4.5 km WNW Amani, Monga Tea Estate, EU control site, 2 August 1992, 30–31 July 1993 (FMNH 150065, 151416, 151185).

### *Nycteris thebaica* E. Geoffroy, 1818

Distribution—*Nycteris thebaica* is broadly distributed from the Arabian Peninsula to South Africa. This species is found in a variety of habitats. Gray et al. (1999) state that it favors open woodland to moister forests, but Monadjem et al. (2010) maintain that quantifying the habitat preference of *N. thebaica* is difficult, although it appears to avoid open grasslands. In Tanzania, this species has been documented on the offshore islands of Mafia, Pemba, and Unguja and several localities on the mainland, including Amani in the East Usambara Mountains (Van Cakenberghe & De Vree, 1998). As currently recognized, *N. thebaica* occurs across a relatively broad elevational and habitat range.

Ecology and Reproduction—During our study, *N. thebaica* was only found in the West Usambara Mountains and only in the 1991 field season. One female was netted at sunset in a *Maesopsis* plantation; it had one embryo in the right uterine horn with a crown–rump length of 3 mm. Another female was found tangled in the thorns of a *Rubus* plant by its wing membranes, about 75 cm off the ground. This species, which is known to forage close to the ground and may even alight to capture invertebrate prey, has been captured in snap traps set on the ground (Kingdon, 1974; Stanley et al., 2005c, 2007b). One specimen was captured in a mist net at dusk in the 1.9-ha fragment next to a large tree with a hole at the base that led to a vertical hollow.

Specimens Examined—**WEST USAMBARA**, 14.5 km NW Korogwe, Ambangulu Tea Estate, 22 July 1991 (FMNH 147220, 147386); 11 km NW Korogwe, Ambangulu Tea Estate, 26–28 July 1991 (FMNH 147221, 147387).

## Family Vespertilionidae

### *Glauconycteris argentata* (Dobson, 1875)

Distribution—*Glauconycteris argentata* has a broad distribution in the central portion of the African continent from Cameroon and Democratic Republic of the Congo eastward to Malawi and Kenya, with the southern-most record being Angola (Monadjem et al., 2010). In Tanzania, this species has been recorded from (north to south) near Gonja (at the base of the South Pare; Stanley et al., 2000) and at Kilosa, Morogoro, and Mwaya (on the northern tip of Lake Tanganyika; Swynnerton & Hayman, 1951).

Ecology and Reproduction—During the course of our inventories, two males were obtained in the East Usambara and one female in the West Usambara. In 1991, a female without signs of active reproduction, but large teats, was netted over a small stream at the edge of the WU control forest. In 1992, a male with abdominal testes measuring 2 by 1 mm and non-convoluted epididymides was captured over an open cistern next to the 2.6-ha Bulwa fragment, and in 1993, a male with abdominal testes was collected over a marshy area near Mbomole village. All specimens were adult, and due to the small sample size, sexes and localities are combined for presentation of external measurements in Table 4.

Specimens Examined—**EAST USAMBARA**, 4.5 km WNW Amani, Monga Tea Estate, EU control site, 4 August 1993 (FMNH 151428); 8 km NWN Amani, Bulwa Tea Estate, 11 August 1992 (FMNH 150074); **WEST USAMBARA**, 12.5 km NW Korogwe, Ambangulu Tea Estate, WU control site, 4 July 1991 (FMNH 147227).

### *Myotis bocagei* (Peters, 1870)

Distribution—*Myotis bocagei* is distributed throughout sub-Saharan Africa and known from Yemen (Simmons, 2005; Monadjem et al., 2010). Swynnerton and Hayman (1951) list this species from Kasanga, in the southern Udzungwa Mountains.

Ecology and Reproduction—One male was collected next to a pond near the Monga Tea factory in 1992. Its testes were abdominal and measured 5 by 3 mm, and the epididymides were not convoluted. Measurements of this single individual are presented in Tables 4 and 6.

Specimen Examined—**EAST USAMBARA**, 6 km NW Amani, Monga Tea Estate, 30 July 1992 (FMNH 150075).

### *Scotophilus dinganii* (A. Smith, 1833)

Distribution—*Scotophilus dinganii* is broadly distributed across sub-Saharan Africa (Simmons, 2005; Monadjem et al., 2010), although molecular data indicate that this species is paraphyletic or the individuals used in the study were misidentified (Trujillo et al., 2009). It has been recorded in Tanzania in habitats ranging from the coastal forests to inland savannah woodlands, such as Tarangire National Park (Robbins et al., 1985; Stanley et al., 2007c).

Ecology and Reproduction—All specimens (five females and two males) from the East and West Usambaras were collected in nets set over running or near standing water. For example, a female was trapped in 1991 over a small stream emerging from the forest of the WU control site, and the

TABLE 4. External measurements (mm) and weight (g) of microbats collected during the 1991–1994 surveys of the South Pare (SP), East Usambara (EU), and Western Usambara (WU) Mountains. Sexes are combined after a one-way ANOVA was conducted to test between sexes and mountain localities for more than three samples (see text). Measurements were taken by both S.M.G. and W.T.S.

| | TL | HB | TV | HF | EAR | FA | WT |
|---|---|---|---|---|---|---|---|
| Rhinolophidae | | | | | | | |
| *Rhinolophus clivosus* S.M.G., EU, ♀, ♂ | | | | | | | |
| Mean ± SD | 106.0 ± 5.29 | | 36.0 ± 3.19 | 10.1 ± 0.94 | 22.6 ± 0.81 | 54.2 ± 1.47 | 16.0 ± 1.08 |
| Range | 95–115 | | 30–41 | 9–12 | 21–24 | 52–56 | 14.5–17.5 |
| n | 11 | | 11 | 11 | 11 | 11 | 11 |
| *Rhinolophus clivosus* W.T.S., EU, ♂ | 97 | 71 | 32 | 12 | 23 | 52 | 15.5 |
| *Rhinolophus clivosus* S.M.G.,WU, ♀, ♂ | | | | | | | |
| Mean ± SD | 106.7 ± 5.58 | | 36.8 ± 3.02 | 11.3 ± 1.36 | 22.8 ± 0.75 | 55.5 ± 1.17 | 16.7 ± 1.81 |
| Range | 95–115 | | 32–41 | 9–14 | 22–24 | 53–57 | 14–20 |
| n | 12 | | 12 | 12 | 12 | 12 | 12 |
| *Rhinolophus clivosus* W.T.S., WU, ♀, ♂ | | | | | | | |
| Mean ± SD | 100.5 ± 4.95 | 74 | 30.5 ± 0.71 | 12.5 ± 0.71 | 21.5 ± 0.71 | 54.0 ± 0.00 | 14.8 ± 0.35 |
| Range | 97–104 | | 30–31 | 12–13 | 21–22 | 54–54 | 14.5–15.0 |
| n | 2 | 1 | 2 | 2 | 2 | 2 | 2 |
| *Rhinolophus clivosus* S.M.G., SP (1100 m), ♀, ♂ | | | | | | | |
| Mean ± SD | 107.8 ± 12.99 | | 36.2 ± 3.27 | 9.4 ± 0.55 | 22.4 ± 0.55 | 56.2 ± 0.84 | 14.9 ± 1.34 |
| Range | 101–131 | | 33–41 | 9–10 | 22–23 | 55–57 | 13–16 |
| n | 5 | | 5 | 5 | 5 | 5 | 5 |
| *Rhinolophus clivosus* W.T.S., SP (2000 m), ♀, ♂ | | | | | | | |
| Mean ± SD | 98.0 ± 1.41 | | 30.0 ± 5.65 | 12.5 ± 0.71 | 21.5 ± 0.71 | 55.5 ± 0.71 | 14.8 ± 1.06 |
| Range | 97–99 | | 26–34 | 12–13 | 21–22 | 55–56 | 14.0–15.5 |
| n | 2 | | 2 | 2 | 2 | 2 | 2 |
| *Rhinolophus deckenii* S.M.G., EU, ♂ | 102 | | 37 | 10 | 24 | 57 | 14.5 |
| *Rhinolophus deckenii* S.M.G., WU, ♂ | 109 | | 37 | 11 | 24 | 56 | 16.5 |
| *Rhinolophus fumigatus* W.T.S., EU, ♀ | 98 | 70 | 30 | 13 | 25 | 56 | 17.5 |
| *Rhinolophus hildebrandti* S.M.G., EU, ♀, ♂ | | | | | | | |
| Mean ± SD | 119.5 ± 7.78 | | 39.0 ± 2.83 | 12.0 ± 1.41 | 34.5 ± 2.12 | 63.5 ± 3.53 | 23.5 ± 1.41 |
| Range | 114–125 | | 37–41 | 11–13 | 33–36 | 61–66 | 22.5–24.5 |
| n | 2 | | 2 | 2 | 2 | 2 | 2 |
| *Rhinolophus hildebrandti* W.T.S., EU, ♀ | 119 | 79 | 38 | 12 | 35 | 62 | 25 |
| *Rhinolophus hildebrandti* S.M.G., WU, ♂ | 122 | | 38 | 15 | 38 | 63 | 23.5 |
| *Rhinolophus simulator* W.T.S., SP (2000 m), ♀ | 73 | 52 | 23 | 9 | 18 | 44 | 6.6 |
| *Rhinolophus swinnyi* W.T.S., SP, ♀ | 78 | | 23 | 9 | 18 | 44 | 6.6 |
| *Rhinolophus swinnyi* S.M.G., EU, ♂ | | | | | | | |
| Mean ± SD | 75.0 ± 1.41 | | 24.0 ± 1.41 | 6.5 ± 0.71 | 17.0 ± 0.00 | 43.5 ± 0.71 | 6.7 ± 0.78 |
| Range | 74–76 | | 23–25 | 6–7 | 17–17 | 43–44 | 6.1–7.2 |
| n | 2 | | 2 | 2 | 2 | 2 | 2 |
| *Rhinolophus swinnyi* W.T.S., EU, ♂ | 73 | 52 | 23 | 9 | 18 | 44 | 6.6 |
| Nycteridae | | | | | | | |
| *Nycteris grandis* S.M.G., EU, ♀ | | | | | | | |
| Mean ± SD | 154.0 ± 7.00 | | 73.3 ± 1.53 | 13.0 ± 1.00 | 33.3 ± 0.58 | 62.3 ± 1.53 | 24.7 ± 0.58 |
| Range | 146–159 | | 72–75 | 12–14 | 33–34 | 61–64 | 24–25 |
| n | 3 | | 3 | 3 | 3 | 3 | 3 |
| *Nycteris thebaica* S.M.G., WU, ♀ | | | | | | | |
| Mean ± SD | 109.3 ± 5.38 | | 53.8 ± 2.75 | 10.0 ± 0.82 | 32.3 ± 2.06 | 43.3 ± 2.06 | 9.0 ± 1.35 |
| Range | 103–116 | | 51–57 | 9–11 | 30–35 | 41–45 | 8–11 |
| n | 4 | | 4 | 4 | 4 | 4 | 4 |
| Vespertilionidae | | | | | | | |
| *Glauconycteris argentata* S.M.G., EU, WU, ♂, ♀ | | | | | | | |
| Mean ± SD | 104.0 ± 2.83 | | 48.5 ± 0.71 | 6.0 ± 0.00 | 12.0 ± 1.41 | 42.0 ± 1.41 | 8.3 ± 0.35 |
| Range | 102–106 | | 48–49 | 6–6 | 11–13 | 41–43 | 8–8.5 |
| n | 2 | | 2 | 2 | 2 | 2 | 2 |
| *Glauconycteris argentata* W.T.S., EU, ♂ | 96 | 56 | 44 | 8 | 12 | 41 | 7 |
| *Myotis bocagei* W.T.S., EU, ♂ | 92 | | 35 | 10 | 14 | 37 | 7.2 |

Table 4. *Continued.*

| | TL | HB | TV | HF | EAR | FA | WT |
|---|---|---|---|---|---|---|---|
| *Scotophilus dinganii* S.M.G., EU, WU, ♀, ♂ | | | | | | | |
| Mean ± SD | 143.5 ± 2.74 | | 59.0 ± 5.34 | 8.8 ± 1.17 | 17.7 ± 0.82 | 56.3 ± 1.03 | 24.8 ± 1.37 |
| Range | 140–148 | | 49–65 | 8–11 | 17–19 | 55–57 | 24–27.5 |
| n | 6 | | 6 | 6 | 6 | 6 | 6 |
| *Scotophilus dinganii* W.T.S., WU, ♀ | 124 | 81 | 47 | 12 | 18 | 53 | 25 |
| *Scotophilus viridis* S.M.G., EU, ♀, ♂ | | | | | | | |
| Mean ± SD | 128.5 ± 2.12 | | 53.5 ± 3.54 | 10.0 ± 0.00 | 17.0 ± 0.00 | 51.5 ± 2.12 | 21.5 ± 2.83 |
| Range | 127–130 | | 51–56 | 10–10 | 17–17 | 50–53 | 19.5–23.5 |
| n | 2 | | 2 | 2 | 2 | 2 | 2 |
| *Pipistrellus hesperidus* S.M.G., WU, ♀ | | | | | | | |
| Mean ± SD | 90.3 ± 2.96 | | 38.2 ± 2.05 | 6.3 ± 0.50 | 11.6 ± 0.53 | 35.3 ± 0.50 | 5.7 ± 0.46 |
| Range | 87–95 | | 36–42 | 6–7 | 11–12 | 35–36 | 5.1–6.5 |
| n | 9 | | 9 | 9 | 9 | 9 | 9 |
| *Pipistrellus hesperidus* S.M.G., EU, WU, ♂ | | | | | | | |
| Mean ± SD | 84.7 ± 4.27 | | 37.1 ± 2.51 | 5.9 ± 0.34 | 11.0 ± 1.05 | 34.3 ± 0.67 | 5.5± 0.32 |
| Range | 78–91 | | 32–40 | 5–6 | 10–13 | 33–35 | 5.0–6.0 |
| n | 10 | | 10 | 10 | 10 | 10 | 10 |
| *Pipistrellus hesperidus* W.T.S., WU, ♀ | 85 | 55 | 32 | 8 | 11 | 40 | 6 |
| *Pipistrellus hesperidus* W.T.S., WU, ♂ | 85 | 55 | 33 | 7 | 11 | 34 | 4.8 |
| *Neoromicia nanus* S.M.G., EU, SP, WU, ♀ | | | | | | | |
| Mean ± SD | 83.1 ± 1.45 | | 36.2 ± 2.86 | 5.2 ± 0.67 | 10.3 ± 0.71 | 32.8 ± 0.67 | 3.3 ± 0.23 |
| Range | 81–86 | | 34–42 | 4–6 | 9–11 | 32–34 | 3–3.6 |
| n | 9 | | 9 | 9 | 9 | 9 | 9 |
| *Neoromicia nanus* S.M.G., EU, SP, WU ♂ | | | | | | | |
| Mean ± SD | 80.5 ± 1.43 | | 35.8 ± 2.97 | 4.8 ± 0.42 | 9.9 ± 0.88 | 31.7 ± 0.67 | 3.3 ± 0.15 |
| Range | 79–83 | | 29–40 | 4–5 | 9–11 | 31–33 | 3–3.5 |
| n | 10 | | 10 | 10 | 10 | 10 | 10 |
| *Neoromicia nanus* W.T.S., WU, ♀ | | | | | | | |
| Mean ± SD | 88.0 ± 0.00 | 48.0 ± 1.41 | 36.5 ± 2.12 | 6.5 ± 0.71 | 11.5 ± 0.71 | 33.5 ± 0.71 | 3.4 |
| Range | 88–88 | 47–49 | 35–38 | 6–7 | 11–12 | 33–34 | |
| n | 2 | 2 | 2 | 2 | 2 | 2 | 1 |
| *Neoromicia nanus* W.T.S., WU, ♂ | | | | | | | |
| Mean ± SD | 76.0 ± 1.41 | 42.5 ± 2.12 | 32.5 ± 0.71 | 6.0 ± 0.00 | 10.5 ± 0.71 | 30.5 ± 0.71 | 2.9 ± 0.14 |
| Range | 75–77 | 41–44 | 32–33 | 6–6 | 10–11 | 30–31 | 2.8–3.0 |
| n | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| *Miniopterus schreibersii* S.M.G., EU, ♀, ♂ | | | | | | | |
| Mean ± SD | 104.5 ± 7.78 | | 49.5 ± 3.54 | 6.8 ± 0.35 | 12.0 ± 0.00 | 43.5 ± 0.71 | 7.5 |
| Range | 99–110 | | 47–52 | 6.5–7 | 12–12 | 43–44 | |
| n | 2 | | 2 | 2 | 2 | 2 | 1 |
| *Miniopterus schreibersii* W.T.S., EU, WU, ♀, ♂ | | | | | | | |
| Mean ± SD | 102.6 ± 7.57 | 57.4 ± 5.35 | 43.9 ± 6.44 | 9.3 ± 0.95 | 11.7 ± 0.76 | 42.7 ± 2.69 | 7.2 ± 0.80 |
| Range | 94–112 | 48–64 | 35–50 | 8.5–10 | 11–13 | 38–46 | 6.1–8.2 |
| n | 7 | 7 | 7 | 7 | 7 | 7 | 7 |

following year a male and female were netted at the same location. One of these males was examined and had abdominal testes that measured 3 by 2 mm with non-convoluted epididymides. In 1993, a female was captured at the same site. In 1992, one female with small teats and no embryos was netted next to a pond in an agricultural zone near Bulwa. Localities and sexes are combined in the external and craniodental measurements (Tables 4 and 6).

Specimens Examined—**EAST USAMBARA**, 8 km NWN Amani, Bulwa Tea Estate, 10 August 1992 (FMNH 150086); **WEST USAMBARA**, 12.5 km NW Korogwe, Ambangulu Tea Estate, WU control site, 3 July 1991, 1–2 September 1992, 22 August 1993 (FMNH 147235, 150087, 150088, 150421, 150422, 151453).

### *Scotophilus viridis* (Peters, 1852)

Distribution—Broadly distributed across sub-Saharan Africa (Simmons, 2005), including different portions of Tanzania (Robbins et al., 1985) and Pemba Island (W. T. Stanley, unpubl. data). Swynnerton and Hayman (1951) list this species from Morogoro, Tanzania. Based on a recent molecular analysis, this species appears to be paraphyletic, and the specific identity of the individuals used in that study need to be reexamined (Trujillo et al., 2009).

Ecology and Reproduction—This species was only obtained in 1992 in the East Usambara Mountains. A male and a female were captured over a stream running through a small marsh below the village of Mbomole. Measurements of these two individuals are presented in Tables 4 and 6.

Specimens Examined—**EAST USAMBARA**, 4.5 km WNW Amani, Monga Tea Estate, EU control site, 4 August 1992 (FMNH 150084, 150085).

### *Pipistrellus hesperidus* Temminck, 1840

Distribution—Kock (2001) recently found *Pipistrellus herperidus* to be distinct from *P. kuhlii* (Kuhl, 1817). *Pipistrellus herperidus* is known from across the African

TABLE 5. Cranio-dental measurements of *Rhinolophus* from the East and West Usambaras. A one-way ANOVA found no significant differences between samples, so the mountains and sexes are combined.

| Measurement | *Rhinolophus clivosus* | *Rhinolophus deckenii* | *Rhinolophus fumigatus* | *Rhinolophus hildebrandti* | *Rhinolophus swinnyi* |
|---|---|---|---|---|---|
| GLS | | | | | |
| Mean ± SD | 22.5 ± 0.30 | 24.1 | 23.2 | 26.9 ± 0.10 | 17.8 ± 0.14 |
| Range | 22.0–23.0 | | | 26.9–27.0 | 17.7–18.0 |
| n | 11 | 1 | 1 | 3 | 3 |
| CCL | | | | | |
| Mean ± SD | 19.9 ± 0.27 | | 20.7 | 24.0 ± 0.14 | 15.7 ± 0.08 |
| Range | 19.5–20.3 | | | 23.9–24.2 | 15.6–15.8 |
| n | 11 | | 1 | 3 | 3 |
| LUTR | | | | | |
| Mean ± SD | 8.4 ± 0.14 | 9.2 | 8.8 | 9.6 ± 0.32 | 6.4 ± 0.09 |
| Range | 8.1–8.6 | | | 9.2–9.9 | 6.3–6.5 |
| n | 12 | 1 | 1 | 3 | 3 |
| PAL | | | | | |
| Mean ± SD | 2.3 ± 0.14 | 2.6 | 2.8 | 3.3 ± 0.33 | 2.0 ± 0.09 |
| Range | 2.1–2.6 | | | 2.9–3.5 | 1.9–2.1 |
| n | 12 | 1 | 1 | 3 | 3 |
| MAST | | | | | |
| Mean ± SD | 10.3 ± 0.21 | 10.8 | 10.9 | 12.2 ± 0.19 | 8.6 ± 0.02 |
| Range | 9.9–10.6 | | | 12.0–12.4 | 8.6–8.7 |
| n | 12 | 1 | 1 | 3 | 3 |
| ZYG | | | | | |
| Mean ± SD | 11.9 ± 0.24 | 12.0 | 12.6 | 14.0 ± 0.30 | 8.7 ± 0.07 |
| Range | 11.4–12.4 | | | 13.8–14.4 | 8.7–8.8 |
| n | 12 | 1 | 1 | 3 | 3 |
| $M^3$-$M^3$ | | | | | |
| Mean ± SD | 8.6 ± 0.20 | 9.0 | 9.2 | 9.8 ± 0.31 | 6.2 ± 0.13 |
| Range | 8.3–8.9 | | | 9.4–10.1 | 6.0–6.3 |
| n | 12 | 1 | 1 | 3 | 3 |
| ALSW | | | | | |
| Mean ± SD | 5.9 ± 0.10 | 5.9 | 5.9 | 7.2 ± 0.23 | 4.6 ± 0.04 |
| Range | 5.7–6.1 | | | 7.0–7.5 | 4.6–4.7 |
| n | 12 | 1 | 1 | 3 | 3 |
| AMSW | | | | | |
| Mean ± SD | 3.6 ± 0.16 | 4.1 | 4.1 | 5.4 ± 0.04 | 3.0 ± 0.09 |
| Range | 3.3–3.9 | | | 5.4–5.4 | 2.9–3.0 |
| n | 12 | 1 | 1 | 3 | 3 |
| IOW | | | | | |
| Mean ± SD | 2.7 ± 0.18 | 2.6 | 2.6 | 2.8 ± 0.04 | 2.3 ± 0.03 |
| Range | 2.3–2.9 | | | 2.7–2.8 | 2.3–2.3 |
| n | 12 | 1 | 1 | 3 | 3 |
| MAND con | | | | | |
| Mean ± SD | 15.2 ± 0.31 | 16.6 | 16.1 | 18.7 ± 0.03 | 11.6 ± 0.08 |
| Range | 14.8–15.7 | | | 18.7–18.7 | 11.5–11.7 |
| n | 12 | 1 | 1 | 3 | 3 |
| LLTR | | | | | |
| Mean ± SD | 8.9 ± 0.18 | 9.8 | 9.4 | 10.4 ± 0.04 | 6.7 ± 0.17 |
| Range | 8.5–9.1 | | | 10.3–10.4 | 6.5–6.8 |
| n | 12 | 1 | 1 | 3 | 3 |
| PAL/LUTR | | | | | |
| Mean ± SD | 0.27 ± 0.02 | 0.28 | 0.32 | 0.34 ± 0.04 | 0.32 ± 0.01 |
| Range | 0.25–0.31 | | | 0.30–0.37 | 0.31–0.32 |
| n | 12 | 1 | 1 | 3 | 3 |

continent, the Canary Islands, and Madagascar (Bates et al., 2006; Monadjem et al., 2010). Further research based on voucher specimens and critical examination of holotypes may show that this taxon consists of several different species (Simmons, 2005). Within Tanzania, this species has been documented at Bagiro on the north slopes of the Uluguru Mountains (Swynnerton & Hayman, 1951). It was not recorded in the South Pare Mountains.

ECOLOGY AND REPRODUCTION—In the East Usambara, one male with abdominal testes was captured over a stream running through a small marsh below the village of Mbomole. In the West Usambara Mountains, we netted 10 females (three in 1991, six in 1992, and one in 1993) and 10 males (seven in 1991 and three in 1992) over a small stream issuing from the forest. Of the two females collected in early July 1991 and examined for reproductive condition, one was not pregnant and the other had an embryo in each uterine horn, the largest measured 3 mm in crown–rump length. Three females collected 1 September 1992 were examined and showed no sign of active reproduction. All males collected had descended testes, which ranged from 4 to 7 mm in length by 3 to 4 mm in width.

Comparison of external measurements recorded by S.M.G. of the West Usambara sample indicated that females were significantly larger than males in total length ($F = 13.7$, $P = 0.002$), hind foot length ($F = 4.9$, $P = 0.04$), and forearm length ($F = 12.0$, $P = 0.003$). Tail length, ear length, and weight were not significantly different between the sexes. Descriptive statistics for this species are presented for each sex, with localities combined, because only two specimens were collected in the East Usambara Mountains (Tables 4 and 6).

Specimens Examined—**EAST USAMBARA**, 4.5 km WNW Amani, Monga Tea Estate, EU control site, 4 August 1992 (FMNH 150076); 8 km NWN Amani, Bulwa Tea Estate, 10 August 1992 (FMNH 150077); **WEST USAMBARA**, 12.5 km NW Korogwe, Ambangulu Tea Estate, WU control site, 3–5 July 1991, 1–4 September 1992, 22 August 1993 (FMNH 147229, 147231–147234, 147398–147402, 150080–150083, 150416–150420, 151435).

### *Neoromicia nanus* (Peters, 1852)

Distribution—*Neoromicia nanus* is broadly distributed across sub-Saharan Africa (Monadjem et al., 2010). This species has been recorded across much of Tanzania, including Amani (Swynnerton & Hayman, 1951).

Ecology and Reproduction—*Neoromicia nanus* was found in all three mountain ranges surveyed during this study. In 1991, we captured two females over a small stream emerging from the forest of the West Usambara control site, neither showed signs of reproductive activity. In 1993, we netted two males, both with abdominal testes, and two females at the same location. In 1992, we caught three males, all near water, in the Bulwa area of the East Usambara Mountains, all of which had scrotal testes that measured 3 by 2 mm with non-convoluted epididymides. In 1993, one male was netted over a reservoir in disturbed forest on this massif.

In the South Pare Mountains, all specimens were collected at the 1100-m site in the second half of July 1993 and taken by local residents from the lower surfaces of banana leaves; the single exception was a female netted over the Mhokuvuta River. Seven specimens of each sex were collected. All males had at least partially descended testes, females collected by local residents were nulliparous, and the netted female was pregnant with an embryo in the left uterine horn measuring 6 mm in crown–rump length.

Specimens collected in the South Pare Mountains and measured by S.M.G. formed an adequate sample to examine patterns of sexual dimorphism in this taxon. Females were significantly larger than males in total length ($F = 16.1$, $P = 0.002$) and forearm length ($F = 10.6$, $P = 0.007$). Small sample sizes of each sex from the East and West Usambara Mountains prevented meaningful comparisons between localities. Descriptive statistics for external measurements are separated by sex and collector in Table 4.

Comments—Thorn et al. (2007) demonstrated the specific validity of *Vesperugo grandidieri*, which had long been synonymized with *N. capensis*, and they created a new genus for this species, *Afropipistrellus*. The samples used in this study came from forest reserves in the East Usambara Mountains, including Amani, Magroto, Longuza, Kwamgumi, Segoma, Kambai, and Nilo. We found no evidence of *V. grandidieri* in the vespertilionids collected during our 1991–1993 studies. The *Neoromicia* we collected have dark roots to the pelage and various cranial features, such as a narrow infraorbital constriction, braincase significantly elevated above the rostrum, and the "helmet" formed by the prominent sagittal and lambdoid sutures, characteristic of *N. nanus* (Rosevear, 1965).

Specimens Examined—**EAST USAMBARA**, 4.5 km WNW Amani, Monga Tea Estate, EU control site, 3 August 1993 (FMNH 151436); 8 km NWN Amani, Bulwa Tea Estate, 10 August 1992 (FMNH 150077–150079); **WEST USAMBARA**, 12.5 km NW Korogwe, Ambangulu Tea Estate, WU control site, 3 July 1991, 22 August 1993 (FMNH 147228, 147230, 151431–151434); **SOUTH PARE**, Chome Forest Reserve, 7 km S Bombo, 17–21 July 1993 (FMNH 151201, 151437–151449).

### Family Miniopteridae
### *Miniopterus schreibersii* (Kuhl, 1817)

Distribution—As currently defined, *Miniopterus schreibersii* is broadly distributed across southern Europe, Asia, Australia, and sub-Saharan Africa, but this taxon includes more than one species (Simmons, 2005; Furman et al., 2010). Recent molecular genetic work on this species complex demonstrated paraphyly between South African and Tanzanian individuals identified as *M. schreibersii* (Appleton et al., 2004). In Tanzania, *Miniopterus* attributed to this species have been collected in montane settings such as Mt. Kilimanjaro (W. T. Stanley, unpubl. data) and the Uluguru Mountains at Bagilo (Swynnerton & Hayman, 1951), as well as in the lowland forest at the base of the South Pare at Gonja (Stanley et al., 2000). Kingdon's (1974) map of this species range shows it occurring across eastern and southern Tanzania, but with no reference to specific locality names or voucher specimens. This species was not captured in the South Pare Mountains during our study.

Ecology and Reproduction—At the control site in the East Usambara Mountains, a male was netted in the ecotone between forest and tea plantation, and another male was captured above a small stream within the forest. In this same range, a female was obtained next to a pond in disturbed forest, and a second female was netted over a marshy area in the same forest. In the West Usambara control site, one female was trapped in 1992 and three females and one male in 1993, all over a small stream emerging from the forest. Of these individuals, the male had abdominal testes that measured 2 by 1 mm with non-convoluted epididymides, and the two examined females showed no sign of reproductive activity. Small sample sizes within each locality precluded critical testing for sexual or geographic differences in external and cranio-dental measurements (Tables 4 and 6).

Specimens Examined—**EAST USAMBARA**, 4.5 km WNW Amani, Monga Tea Estate, EU control site, 1–3 August 1993 (FMNH 151206, 151207); 4.5 km ESE Amani, Monga Tea Estate, EU control site, 17–23 August 1992 (FMNH 150089, 150091); **WEST USAMBARA**, 12.5 km NW Korogwe, Ambangulu Tea Estate, WU control site, 1 September 1992, 22 August 1993 (FMNH 150090, 151454–151457).

## Discussion

### Faunistics of the Three Studied Massifs

The surveys we conducted in the East and West Usambara and the South Pare Mountains were not specifically focused on bats, but rather were part of a large-scale project to

Table 6. Cranio-dental measurements of select vespertilionids and miniopterids from the East and West Usambaras. Mountains and sexes are combined.

| Measurement | *Myotis bocagei* | *Scotophilus dinganii* | *Scotophilus viridis* | *Pipistrellus hesperidus* | *Neoromicia nanus* | *Miniopterus schreibersii* |
|---|---|---|---|---|---|---|
| GSKL | | | | | | |
| Mean ± SD | 15.5 | 22.0 ± 0.38 | 19.6 ± 0.31 | 13.0 ± 0.15 | 11.5 ± 0.25 | 14.8 ± 0.12 |
| Range | | 21.4–22.5 | 19.4–19.8 | 12.7–13.2 | 11.2–11.8 | 14.7–15.0 |
| n | 1 | 6 | 2 | 11 | 4 | 5 |
| CIL | | | | | | |
| Mean ± SD | 14.1 | 20.2 ± 0.44 | 18.6 ± 0.08 | 12.3 ± 0.19 | 10.9 ± 0.24 | 14.2 ± 0.15 |
| Range | | 19.8–20.8 | 18.5–18.6 | 12.0–12.7 | 10.6–11.1 | 14.2–14.5 |
| n | 1 | 6 | 2 | 11 | 4 | 5 |
| ZYG | | | | | | |
| Mean ± SD | 9.46 | 14.8 ± 0.15 | 13.4 ± 0.03 | 8.6 ± 0.09 | 7.0 ± 0.36 | 8.1 ± 0.05 |
| Range | | 14.6–15.0 | 13.4–13.4 | 8.4–8.7 | 6.6–7.3 | 8.0–8.2 |
| n | 1 | 6 | 2 | 7 | 3 | 4 |
| IOW | | | | | | |
| Mean ± SD | | 4.8 ± 0.11 | 4.6 ± 0.20 | | 3.2 ± 0.08 | |
| Range | | 4.7–4.9 | 4.5–4.8 | | 3.1–3.3 | |
| n | | 6 | 2 | | 4 | |
| POW | | | | | | |
| Mean ± SD | 3.55 | | | 3.7 ± 0.10 | | 3.6 ± 0.08 |
| Range | | | | 3.6–3.9 | | 3.6–3.7 |
| n | 1 | | | 11 | | 5 |
| MAST | | | | | | |
| Mean ± SD | 7.75 | 12.4 ± 0.30 | 11.3 ± 0.25 | | 6.5 ± 0.21 | 8.1 ± 0.07 |
| Range | | 12.1–12.8 | 11.2–11.5 | | 6.2–6.8 | 8.1–8.2 |
| n | 1 | 6 | 2 | | 4 | 5 |
| BW | | | | | | |
| Mean ± SD | 7.5 | 9.8 ± 0.24 | 9.1 ± 0.04 | 6.5 ± 0.11 | 5.8 ± 0.17 | 7.5 ± 0.14 |
| Range | | 9.3–10.0 | 9.0–9.1 | 6.4–6.7 | 5.6–6.0 | 7.3–7.6 |
| n | 1 | 6 | 2 | 11 | 4 | 5 |
| PAL | | | | | | |
| Mean ± SD | 5.85 | 10.7 ± 0.35 | 9.9 ± 0.11 | | 4.1 ± 0.08 | 5.4 ± 0.05 |
| Range | | 10.2–11.1 | 9.8–9.9 | | 4.0–4.2 | 5.3–5.5 |
| n | 1 | 6 | 2 | | 4 | 5 |
| LW | | | | | | |
| Mean ± SD | | | | | 4.0 ± 0.28 | 3.8 ± 0.04 |
| Range | | | | | 3.8–4.4 | 3.7–3.8 |
| n | | | | | 4 | 5 |
| MAND con | | | | | | |
| Mean ± SD | 11.1 | 15.2 ± 0.68 | 14.1 ± 0.17 | 9.0 ± 0.20 | 7.5 ± 0.16 | 10.6 ± 0.12 |
| Range | | 14.4–16.1 | 13.9–14.2 | 8.6–9.3 | 7.3–7.7 | 10.5–10.7 |
| n | 1 | 6 | 2 | 11 | 4 | 5 |
| $I^1$-$M^3$ | | | | | | |
| Mean ± SD | 6.54 | | | | | 6.6 ± 0.05 |
| Range | | | | | | 6.5–6.6 |
| n | 1 | | | | | 5 |
| $C^1$-$M^3$ | | | | | | |
| Mean ± SD | 5.44 | 7.1 ± 0.14 | 6.6 ± 0.01 | 4.7 ± 0.10 | 3.9 ± 0.17 | 5.5 ± 0.03 |
| Range | | 7.0–7.8 | 6.6–6.6 | 4.5–4.9 | 3.7–4.0 | 5.5–5.6 |
| n | 1 | 6 | 2 | 11 | 4 | 5 |
| $C^1$-$C^1$ | | | | | | |
| Mean ± SD | 3.95 | 7.4 ± 0.24 | 6.5 ± 0.20 | 4.1 ± 0.13 | 3.4 ± 0.12 | 4.0 ± 0.05 |
| Range | | 7.1–7.8 | 6.4–6.6 | 4.0–4.4 | 3.2–3.5 | 3.9–4.1 |
| n | 1 | 6 | 2 | 10 | 4 | 5 |
| $M^3$-$M^3$ | | | | | | |
| Mean ± SD | 5.93 | 9.4 ± 0.19 | 8.4 ± 0.05 | | 4.6 ± 0.20 | 5.8 ± 0.04 |
| Range | | 9.2–9.7 | 8.3–8.4 | | 4.3–4.8 | 5.8–5.9 |
| n | 1 | 6 | 2 | | 4 | 5 |
| UPMOLS | | | | | | |
| Mean ± SD | 4.71 | | | | | 4.6 ± 0.06 |
| Range | | | | | | 4.5–4.7 |
| n | 1 | | | | | 5 |

Table 6. *Continued.*

| Measurement | *Myotis bocagei* | *Scotophilus dinganii* | *Scotophilus viridis* | *Pipistrellus hesperidus* | *Neoromicia nanus* | *Miniopterus schreibersii* |
|---|---|---|---|---|---|---|
| $I_1$-$M_3$ | | | | | | |
| Mean ± SD | 7 | 8.9 ± 0.13 | 8.1 ± 0.27 | 5.0 ± 0.12 | | 6.9 ± 0.09 |
| Range | | 8.7–9.1 | 7.9–8.3 | 4.8–5.2 | | 6.8–7.1 |
| n | 1 | 6 | 2 | 11 | | 5 |
| lowermols | | | | | | |
| Mean ± SD | 5.18 | | | | | 5.3 ± 0.05 |
| Range | | | | | | 5.3–5.4 |
| n | 1 | | | | | 5 |

inventory small terrestrial mammals. Hence, the bat captures were largely opportunistic, and the resulting species lists and measures of species richness should be considered preliminary. Species diversity across these mountains (Table 1) differs with the highest number from the East Usambara (n = 16), followed by the West Usambara (n = 11), and then the South Pare (n = 5). This variation might reflect patterns of species richness, but our measures are closely associated with sampling effort (see below).

Species common to all three massifs include two pteropodids (*Epomophorus wahlbergi* and *Lissonycteris angolensis*), one *Rhinolophus* (*R. clivosus*), and one vespertilionid (*Neoromicia capensis*). Of the 20 species documented during our bat surveys on these three mountains, taxa only found on a single massif include: *Rousettus lanosus* and *Rhinolophus simulator* (South Pare, 10% of total); *Myonycteris relicta* and *Nycteris thebaica* (West Usambara, 10% of total); and *Rousettus aegyptiacus, Rhinolophus deckenii, R. fumigatus, R. swinnyi, N. grandis, Myotis bocagei*, and *Scotophilus viridis* (East Usambara, 35% of total).

Sampling effort may explain some of these differences in species richness among the massifs. Mist nets set specifically for bats were in place in the South Pare for a total of 12 nights (eight at 1100 m and four at 2000 m), in the West Usambara for a total of 20 nights (11 in 1991, seven in 1992, two in 1993), and in the East Usambara for a total of 27 nights (three in 1991, 16 in 1992, eight in 1993). Furthermore, incidental trapping effort took place in the East and West Usambara Mountains associated with bird nets set for W. D. Newmark's study of understory birds. Bats found in the bird nets, all within forest, include *Epomophorus wahlbergi, Lissonycteris angolensis, Myonycteris relicta, Rhinolophus clivosus*, and *R. deckenii*; these species were also captured in nets we set specifically for bats.

### Other Species of Bats Recorded in the Usambara Mountains and Nearby Regions

Comparing taxa previously reported from these massifs to those we collected can evaluate the effectiveness of bat inventories of the Usambaras (Table 7). An important caveat is that many taxa cited in the literature are not necessarily based on voucher specimens from which identifications can be properly verified.

A number of other taxa with verifiable voucher specimens add information regarding the regional fauna. Particularly interesting in this regard is a number of species that have been documented in the Usambaras outside of our inventories, which include the synanthropic occurrence of *Chaerephon pumilus* (Cretzschmar, 1830–1831) at Amani and the holotype of *Otomops martiensseni* (Matschie, 1897), a species poorly represented among collections of Tanzanian bats (Table 7). With the addition of these other records, 46 species are cited from the East Usambara, 28 of which were not recorded during our inventories of this massif.

Numerous other species are recorded to the east—specifically, between the foot of the East Usambara and Tanga along the coast, including *Hipposideros cyclops* (Temminck, 1853) from the Kwamgumi Forest Reserve (Stanley et al., 2005c), and *Triaenops persicus* Dobson, 1871, *Coleura afra* (Peters, 1852), and *Miniopterus minor* Peters 1867 from the Amboni Caves (Weyeneth et al., 2008; W. T. Stanley, unpubl. data).

Of the species listed in Table 7, certain ones, particularly some of those without associated voucher specimens, appear to be anomalous. For example, the eastern edge of the distribution of *Scotophilus nucella* Robbins, 1973, is thought to be Uganda, and other than the dubious records cited in Table 7 of *Neoromicia flavescens* (Seabra, 1900), this species is not known from Tanzania (Simmons, 2005) and is a nomen dubium (Thorn et al., 2007). *Epomophorus anurus* Heuglin, 1864, is a synonym of *E. labiatus* (Temminck, 1837), and the recorded distribution of this taxon within Tanzania is in the northwest (Bergmans, 1988).

### Comparisons to Other Regional Sites

The diversity of species documented during this study in montane habitats of three Eastern Arc Mountains results from three years (two months each year) of occasional and opportunistic sampling. These limited efforts collected fewer species than known in lowland zones or habitats at the same general elevation but with different forest type in western Tanzania (Table 8). The two sites we use in these comparisons are Gonja Forest Reserve at 500 m at the base of the South Pare Mountains (Stanley et al., 2000) and Minziro Forest at 1150 m in northwestern Tanzania (Stanley & Foley, 2008).

Comparison of sampling effort (net hours), number of individuals, and number of species are presented in Table 8. We stress that these comparisons are rough because nets used at many of the montane sites were left in place for the entire night unmonitored, and some bats undoubtedly escaped. Additionally, the question of net placement at each site needs to be taken into account. For example, the stream that the Gonja net spanned may have been the only water source for some distance, and bats came to drink or catch insects. Nonetheless, species diversity and net trap success generally increase at both Gonja and Minziro, compared with the montane sites. In the Gonja dry forest, Stanley et al. (2000) caught 27 bats representing 11 species using one 12-m net for 2.5 h per night for six nights (12.5 net hours). Of these 11 species, eight were documented during our study of the

Table 7. Different bat species reported in the Usambara Mountains and surrounding areas but not recorded during our surveys of the regional montane forests. Specific details on the different localities are presented at the foot of the table.

| Species | Locality[1] | Reference |
|---|---|---|
| *Epomophorus anurus* | 10 | Frontier-Tanzania |
| *Rousettus lanosus* | 2 | Frontier-Tanzania |
| *Rhinolophus eloquens* | 1, 2, 3, 8, 9, 10 | Frontier-Tanzania |
| *Rhinolophus landeri* | 2, 7, 10, 12, 14, 16 | Frontier-Tanzania |
| *Rhinolophus maendeleo* | 4 | Kock et al. (2000) |
| *Hipposideros caffer* | 2, 3, 7, 15 | Frontier-Tanzania |
| *Hipposideros cyclops* | 13, 14 | Frontier-Tanzania |
| *Hipposideros ruber* | 2, 3, 7, 10, 11, 12, 14, 15 | Frontier-Tanzania |
| *Triaenops persicus* | 1, 2, 7, 10, 11, 12, 14 | Frontier-Tanzania |
| *Taphozous mauritianus* | 11 | Frontier-Tanzania |
| *Nycteris hispida* | 3, 11 | Frontier-Tanzania |
| *Nycteris macrotis* | 3, 8 | Frontier-Tanzania |
| *Chaerephon ansorgei* | 11 | Frontier-Tanzania |
| *Chaerephon pumilus* | 1, 5 | Frontier-Tanzania, Aspetsberger et al. (2003) |
| *Otomops martiensseni* | 6 | Specimens in FMNH |
| *Mops brachyptera* | 1, 9, 11, 12 | Frontier-Tanzania |
| *Nycticeinops schlieffeni*[2] | 16 | Frontier-Tanzania |
| *Scotophilus nucella* | 3, 10, 11 | Frontier-Tanzania |
| *Vesperugo grandidieri*[3] | 1, 2, 3, 5, 7, 9, 10, 11, 13, 14 | Thorn et al. (2007), Frontier-Tanzania |
| *Neoromicia flavescens*[4] | 3, 9, 11, 13 | Frontier-Tanzania |
| *Neoromicia rendalli*[5] | 10 | Frontier-Tanzania |
| *Scotoecus hindei* | 11 | Frontier-Tanzania |
| *Scotoecus hirundo* | 1, 8, 11 | Frontier-Tanzania |
| *Mimetillus moloneyi* | 1 | Frontier-Tanzania |
| *Miniopterus fraterculus* | 2, 10, 12 | Frontier-Tanzania |
| *Miniopterus minor* | 3, 7 | Frontier-Tanzania |
| *Kerivoula argentata* | 3, 7 | Frontier-Tanzania |

[1] Details on different localities: (1) Tanzania, Tanga Region, Muheza District, Magoroto Oil Palm Estate, 38°45′E, 5°7′S, 650–770 m (Cunneyworth et al., 1996b). (2) Tanzania, Tanga Region, Muheza District, Amani Nature Reserve, 38°30′34″–38°40′6″E, 5°14′10″–5°4′30″S, 190–1130 m (Doody et al., 2001b). (3) Tanzania, Tanga Region, Muheza District, Kambai Forest Reserve, 38°42′E, 5°0′S, 220–590 m (Cunneyworth et al., 1997b). (4) Tanzania, Tanga Region, Lushoto District, West Usambara Mountains, Mazumbai Forest Reserve, 38°15′E, 4°25′S, 1400–1900 m (Kock et al., 2000). (5) Amani (Thorn et al., 2007). (6) Magrotto Plantation, west of Tanga, southeastern Usambara Mountains (FMNH specimens). (7) Tanzania, Tanga Region, Muheza District, Bamba Ridge Forest Reserve, 38°47′E, 4°58′S, 150–1033 m (Cunneyworth et al., 1996c). (8) Tanzania, Tanga Region, Muheza District, Kwamarimba Forest Reserve, 38°45′E, 5°2′S, 95–445 m (Cunneyworth et al., 1996a). (9) Tanzania, Tanga Region, Muheza District, Longuza North Forest Reserve, 38°41′E, 5°2′S, 95–345 m (Cunneyworth et al., 1997a). (10) Tanzania, Tanga Region, Muheza District, Mtai Forest Reserve, 38°44′–38°48′E, 4°51′–4°54′S, 180–1016 m (Doggart et al., 1999b). (11) Tanzania, Tanga Region, Muheza District, Kwamgumi Forest Reserve, 38°44′–38°47′E, 4°55′–4°57′S, 150–915 m (Doggart et al., 1999a). (12) Tanzania, Tanga Region, Muheza District, Manga Forest Reserve, 38°45′–38°47′E, 5°0′–5°2′S, 120–360 m (Doggart et al., 1999c). (13) Tanzania, Tanga Region, Muheza District, Segoma Forest Reserve, 38°43′–38°47′E, 4°57′–5°1′S, 80–920 m (Doody et al., 2001a). (14) Tanzania, Tanga Region, Korogwe and Muheza Districts, Nilo Forest Reserve, 38°37′–38°41′E, 4°50′–4°59′S, 400–1506 m (Beharrell et al., 2002). (15) Tanzania, Tanga Region, Muheza District, Mlinga Forest Reserve, 38°44′–38°46′E, 5°4′–5°5′S, 220–1069 m (Hall et al., 2002). (16) Tanzania, Tanga Region, Muheza District, Mgambo Forest Reserve, 38°47′–38°49′E, 4°44′–4°47′S, 320–820 m (Oliver et al., 2002).

[2] Identified as *Nycticeius schlieffeni.*

[3] Identified as *Pipistrellus g. grandidieri.*

[4] Identified as *Pipistrellus flavescens* or *Eptesicus flavescens.*

[5] Identified as *Eptesicus rendalli.*

Table 8. Sampling effort and resulting numbers of individuals and species caught for three Eastern Arc Mountains, Gonja Forest Reserve, a dry lowland forest, and Minziro Forest Reserve, a Guinea-Congo forest in western Tanzania. Sites marked with an asterisk (*) represent efforts that included nets left operational the entire night. Sites not marked with an asterisk represent efforts in which the net was opened for only two to three hours at a time.

| Site | Elevation (m) | Year | Net hours | No. of individuals | No. of species |
|---|---|---|---|---|---|
| East Usambara* | 900–1150 | 1992 | 132 | 17 | 7 |
| East Usambara* | 900–1150 | 1993 | 18 | 8 | 5 |
| West Usambara* | 1150–1300 | 1991 | 96 | 25 | 4 |
| West Usambara* | 1150–1300 | 1992 | 24 | 13 | 4 |
| West Usambara* | 1150–1300 | 1993 | 24 | 10 | 5 |
| South Pare* | 1100 | 1993 | 12 | 23 | 2 |
| South Pare | 2000 | 1994 | 4 | 5 | 3 |
| Gonja | 500 | 1993 | 12.5 | 27 | 11 |
| Minziro | 1050 | 2006 | 8 | 58 | 9 |

montane bat fauna of the East Usambara, West Usambara, and South Pare Mountains. The three species only found at Gonja are *Hipposideros caffer* (Sundevall, 1846), *Nycteris hispida* (Schreber, 1775), and *Scotoecus hirundo* (de Winton, 1899). At the 1100-m site in the South Pare Mountains, approximately 8 km away from Gonja, 12 net hours were accrued with a single net, and 23 individuals were captured, representing only two species.

In the Minziro Forest at 1150 m, which consists of a Guinea-Congo forest, a single net was in place at the edge of a pond for four consecutive nights, each night for two hours (1800–2000 hrs), accruing eight net hours, and 58 bats were captured of nine species (Stanley & Foley, 2008). Only two of these, *Nycteris grandis* and *Neoromicia nanus*, were captured at the three Eastern Arc Mountain sites reported herein. Results from efforts conducted at a similar elevation in the East Usambara (separated by year), show notably fewer captures and slightly lower species diversity (Table 8). Thus, although these comparisons are preliminary, the bat fauna of the montane localities of the South Pare and East and West Usambara Mountains documented during our study appears to be less rich than other sites in Tanzania.

To have a more comprehensive view of the bat fauna of the Usambara and South Pare Mountains, more systematic bat surveys are needed, covering a greater range of elevations and variety of habitats than during our preliminary work. These data will be important for providing more detailed information, which will provide further insights into the faunistics and biogeography of the regional bat fauna.

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